Compumotor

Bulletin OM-8200-KH

Operator's Manual

DO 64826

120 MOTOR TURN / REV

+ 1 MOTOR TURN 5000 STEPS

5000 x 120 = 600,000 STEPS / REV

SERVO

5000 x ( ) = 360,000

72

600,000 / 360 = 1667

1667 / 5000 = .333

72 x (x) = 600,000

5000 / 360,000 = ( ) / 600,000

(x) = 833333

KH-Drive

P/N: 88-006936-01

Parker Hannifin Corporation
Compumotor Division
1179 N. McDowell Blvd.
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COMPUMOTOR CORPORATION

KH-series Operator's Manual

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INTRODUCTION

Description

The KH-Series is a complete Brushless Servo positioning system. Ready to run, the KH-Series system consists of an Brushless servomotor, brushless resolver feedback, and a microprocessor based closed loop drive amplifier. Digital electronics simplify operation and maintenance and improve performance.

The KH-Series drive accepts digital STEP and DIRECTION inputs to control position and velocity. The onboard microprocessor monitors both the pulse inputs and the resolver feedback, then determines the proper current levels to apply to the motor. The system offers speeds to 6000 RPM, and torques to 4100 oz.-in. continuous. (8000 oz.-in.) peak.

Closed-loop performance is simplified by microprocessor control and a sophisticated servo algorithm. All servo performance parameters are stored in non-volatile EEPROM memory, eliminating analog potentiometer adjustments required in conventional systems. KH Series Motor/Drives are supplied as packaged systems, factory compensated for typical load and performance requirements.

KH-Series systems are readily installed and operated by personnel with little or no training in servo controls. In some applications, no adjustments will be required. For most applications simple pushbutton adjustments provided will set up the servo to handle the load. In addition, an RS-232 interface is provided to access all servo parameters for the few cases where critical adjustment is required.

The power amplifier section of KH-Series drives utilizes a rugged bipolar 8 kHz pulse width modulation (PWM) current control. This time tested design improves reliability, power regulation and low speed smoothness, and results in quiet operation.

KH-Series system features include:

* Brushless servomotor
* Brushless resolver feedback
* Speeds to 6000 RPM
* Torques to 4100 oz in. (8000 oz.-in. peak)
* USER PROGRAMABLE steps per revolution resolution
* 5000 steps per revolution STANDARD
* Microprocessor control; no drift, no analog pots to adjust
* Fan cooled drive enclosure
* 8 kHz PWM switching frequency
* Accepts digital STEP and DIRECTION inputs
* Servo parameters factory set and stored in non-volatile EEPROM memory
* High noise immunity due to optical isolation and brushless resolver technology
* Simple pushbutton adjustment of servo compensation
* LED Fault Indicators
* RS-232 INTERFACE

Pre Installation

Please read this entire manual carefully before attempting to install or operate the K-Series system. If any questions should arise which are not covered to your satisfaction in this manual, please call your Parker Compumotor field applications engineer for assistance.

INSPECTION

Your KH-Series should be inspected upon receipt for obvious damage to its shipping container. Report any such damage to the shipping company as soon as possible, as Parker Compumotor cannot be held responsible for damage incurred in shipment. The K-Series should then be carefully unpacked and inspected for the following items to be present and in good condition.

1. K-Drive unit (KH-XX, KHX-XX,)
2. Motor
3. Motor cable (round MS connector one end, 4 leads with ring terminals installed on other end).
4. Resolver cable (round MS connector one end, 9 Pin D connector other end)
5. This manual

WARRANTY

Your K-Drive is warranted against manufacturing defects for one year from the date of purchase. Should you have questions about operating the Drive, your Compumotor representatives and distributors stand ready to support your individual needs. Call Compumotor Corporation at the number listed below to get the name, address and phone number of the Compumotor representative nearest you.

Should return of your Motor Controller be required to effect repairs or upgrades, do the following:

1. Get the serial number and the model number of the defective unit, and a purchase order number to cover repair costs in the event the unit is determined to be out of warranty by Compumotor upon inspection.

2. Call Compumotor for a Return Material Authorization Number (RMA) at 800-358-9068 except in California. In California, call 707 778-1244.

584 7558

3. Ship the unit to: Compumotor Corporation
1179 N. McDowell Blvd.
Petaluma, CA 94952
Attn: RMA# xxxxxxxx

INSTALLATION AND HOOKUP

General

Safety is of primary importance when installing a motion control system. This section outlines installation guidelines with the safety of the operator and the equipment in mind. The installer of this equipment should become familiar with this section and with local and national codes which pertain to installation of electrical equipment before attempting the installation.

System Installation Recommendations

Special attention should be given to the environment in which the equipment will be operated, the layout and mounting, and the wiring and grounding practices used, to ensure trouble free operation. These recommendations are intended to aid the user in easily and safely integrating Compumotor equipment in his manufacturing facility.

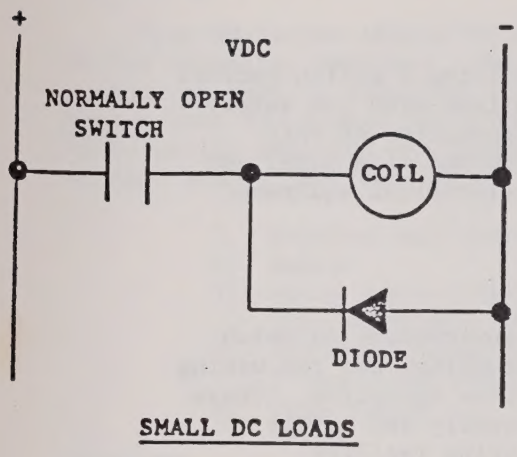
Industrial environments often contain conditions which may adversely affect solid state equipment. Electrical noise, atmospheric contamination, or excess heat may be generated by other equipment may affect the installation and operation of the KH system.

Electrical Noise

When a K-Series system will be operated in an environment where there is an excess amount of electrical noise, special care must be taken to eliminate sources of possible noise interference. Potential sources of electrical noise include inductive devices such as solenoids, relays, motors, and motor starters when operated by a hard contact.

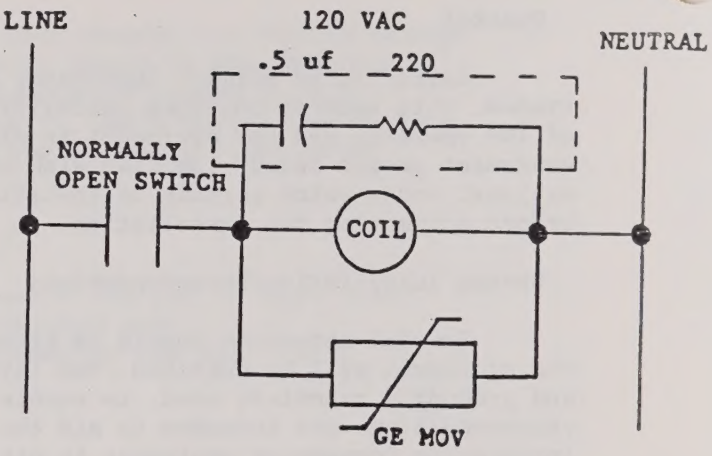
Noise suppression may be necessary when these types of devices are connected to the same AC power source or are in close proximity to electronic equipment. The illustration below shows some recommended suppression devices for most small loads. For best results these should be installed as close as possible to the inductive load.

At the same time it should be noted that the KH series is capable of delivering 40 amps (peak) on a 325 volt rail to the motor. This is pulse width modulated at a 8 KHZ rate. Therefore, the K drive is an electrical noise source and should be treated as such.

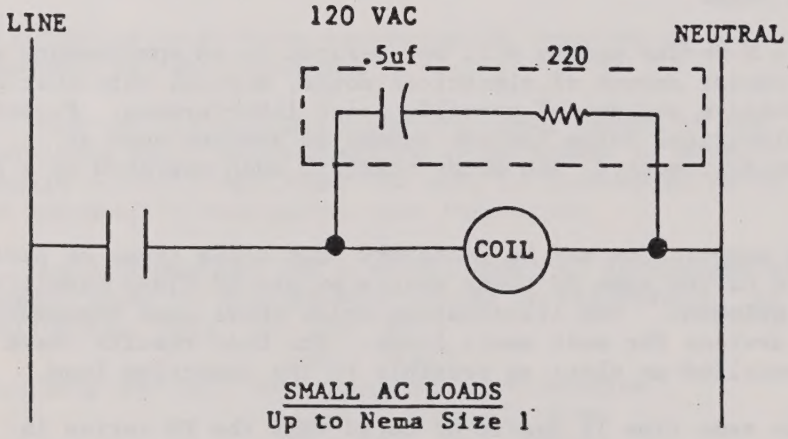


SMALL DC LOADS

Note: Peak Inverse Voltage (PIV)
Should Be Twice VDC



LARGE AC LOADS
Nema Size 1 and larger



SMALL AC LOADS
Up to Nema Size 1

NOISE SUPPRESSION DEVICES

Figure 1. Recommended Suppression For Small Inductive

Enclosure Considerations

The K-Drive should generally be installed in an enclosure to protect it against atmospheric contaminants such as oil, moisture, and dirt. The National Electrical Manufacturers Association has established standards which define the degree of protection provided by electrical enclosures. The enclosure should conform to NEMA Type 12 standards if the intended environment is industrial in nature and contains airborne contaminants. Proper layout of components is required to ensure sufficient cooling of equipment within the enclosure.

Grounding Information

Proper grounding of electrical equipment is essential to assure the safety of personnel. The affects of electrical noise due to electromagnetic interference (EMI) can also be reduced by grounding. All Compumotor equipment should be properly grounded. A good source of information on grounding requirements is the National Electrical Code published by the National Fire Protection Association of Boston, Massachussets. Grounding should also conform to applicable local codes and ordinances.

In general, all components and enclosures must be connected to earth ground through a grounding electrode conductor to provide a low-impedance path for ground fault or noise induced currents. All earth ground connections must be continuous and permanent. Compumotor recommends a single point grounding setup. You should prepare Components and mounting surfaces prior to installation so that good electrical contact is made between mounting surfaces of equipment and enclosure. Remove the paint from equipment surfaces where the ground contact will be bolted to a panel and use star washers to assure a solid bare metal contact. A 8 gauge or larger copper wire should be used to connect each component from a mounting stud to a central ground bus. Permanent ground connections should be made to only one mounting bracket on each piece of equipment If this method is used, there should be no connection to the ground terminal of the AC Power connector.

For temporary installations, or when the grounding method described above cannot be implemented, the GROUND terminal on the AC power connector must be connected to earth ground.

Mounting

Panel Layout

A good panel layout is essential for trouble free operation of the KH-Drive. The KH-Drive relies on fan cooling to maintain the temperature within its operating range. Panel mounting requires consideration of this to allow sufficient space for unrestricted airflow over the heatsink. Because the fan draws air upward over the heatsink, the air directly beneath the unit must not exceed the recommended maximum ambient temperature of 50 degrees C. The limiting factor is the heatsink temperature, which must be no greater than 65°C. The KH-Drive has a temperature sensor on the amplifier board which prevent the drive from overheating by shutting down the drive. An LED indicator on the drive will indicate an over temperature condition.

When the KH drive is to be mounted in an enclosure it will be necessary to provide means to dissipate the heat generated in the drive. As a guideline plan to dissipate some 500 watts for each KH drive in your panel. The actual dissipation could vary depending on duty cycle, motor size and load inertia, and hanging weight. 500 watts represents a KH-series motor running at its maximum allowable current for a continuous duty operation. Most applications will produce less heat than this. You can make an approximation of the derating possible if you know the percentage of dwell time versus the time when the motor is drawing current(assuming no hanging loads). The time when the motor is not moving is when it is not drawing current. Thus if you have a low duty cycle the actual heat produced by the drive could be as low as 100 watts. If you know that the motor will be sitting idle for 50% of the time (based on a 15 minute time window) then you could expect 100 watts of base energy plus 50% of the 400 watts of motor related energy to give a total of 300 watts of heat to dissipate.

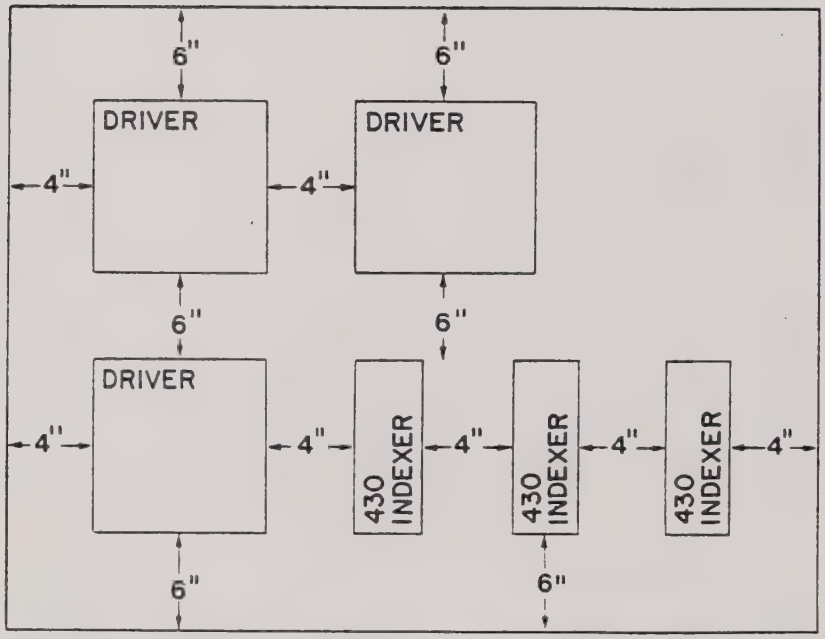
The following rules should be observed when mounting KH-Series drives in an enclosure:

1. The vertical distance between the KH-Drive and other equipment or the top and bottom of the enclosure should be no less than 6 inches.

2. The horizontal distance between the KH-Drive and other equipment or the side walls of the enclosure should be no less than 4 inches.

3. Because motor/drive products produce more heat than indexers, drives should not be mounted directly below indexers.

4. Large heat producing equipment should not be mounted directly beneath the KH-Drive.



PANEL LAYOUT RECOMMENDATIONS

Figure 2. Recommended Panel Layout Guidelines

Panel Mounting

The KH-Drive has "L" shaped mounting brackets, notched with keyhole type slots to accept screws on either end to facilitate mounting to flat panel surfaces. Since the drive weighs about 30 lbs you should plan for suitable hardware. 10-32 screws into captured nuts should do nicely. Since the fan can set up vibrations locking the screws is advisable. You should consider the problems of removing and installing the KH-Drive, since it's heavy enough to be difficult to manage with one hand, and the 240 volt power lines do represent a safety hazard it is advisable to have a power interlock that prevents the drive mountings from being removed with the power on.

CAUTION HIGH VOLTAGES

The KH drive has 240 V.A.C. three phase, 110 V.A.C. single phase and 325 D.C. volts modulated at 8 KHZ, present. All of these represent hazards to personnel and equipment. Qualified engineers should install this equipment so as to reduce the risk to any unqualified workers in the area.

Motor Mounting

When mounting a servo motor, several factors require important consideration to ensure long life and trouble free operation. This section provides useful information intended to help in the proper installation of the brushless servo motors.

The brushless motor should be mounted using the four flange bolts and centered by the pilot on the front face. Foot mount configurations of the motor are a less desireable alternative because the torque of the motor is not evenly distributed around the motor case. Further any side load on the motor shaft is multiplied by a much longer lever arm when a foot mount is used than when a face flange mount is selected.

It is expected that the motors used with the KH-drive will produce very large torques. The motors will also produce high accelerations. This combination can shear shafts and mounting hardware if the mounting is not up to the task. The high accelerations can produce shocks and vibrations that require much heavier hardware than would be expected for static loads of the same magnitude. The motor under certain move profiles can set up low frequency vibrations in the mounting structure. These vibrations will cause fasteners to loosen if they are not locked. (Elastic nuts are nice.) This same vibration caused by cycling the motor can induce metal fatigue in structural members if harmonic resonances are induced by the move profiles you are using.

You should have a mechanical engineer check your machine design to insure that the mounting structure is adequate to the task.

Refer to appendix for motor drawings.

MOTOR COUPLING

Shaft Misalignments -- Drive line component tolerances will always cause misalignments between the ends of coupled shafts. The misalignments that can occur include parallel, angular and end float. They can and will exist in any combination.

Parallel misalignment is the offset of two mating shaft centerlines although the centerlines remain parallel to each other. Angular misalignment is when two shaft centerlines intersect at some angle other than zero degrees. End float is a change in the relative distance between the ends of the two shafts.

Special couplings are used to accommodate these misalignments and to transmit the desired torque. The coupling manufacturer should be consulted to assure that the coupling is being used within its ratings; both for torque capacity and misalignment capabilities.

Coupling Types -- Shaft couplings may be divided into three types; single-flex, double flex and rigid. Like a hinge, a single flex coupling accepts angular misalignment only. A double-flex coupling accepts both angular and parallel misalignments. Both types, depending on their design, may or may not accept end play. A rigid coupling cannot compensate for any misalignment.

Whenever two shafts are joined that are fixed in the radial and angular direction, a double-flex coupling should be used. A single-flex coupling should not be used because it does not permit any parallel misalignment and the only compensation for parallel misalignment will be by bending the shafts, which will cause excessive bearing loads and premature failure.

When a single-flex coupling is used, one and only one of the shafts must be free to move in the radial direction without constraint. A double -flex coupling should not be used in this situation because it will allow too much freedom and rotate eccentrically, which will cause large vibrations and immediate failure.

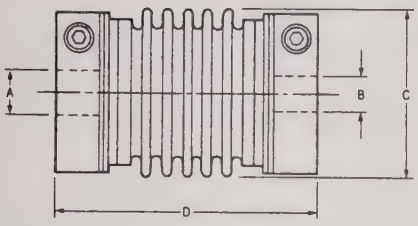
Rigid Couplings are not recommended, they should only be used if the motor is on some form of floating mounts that will allow for alignment compensation.

Parker Compumotor does offer a line of suitable couplers for use

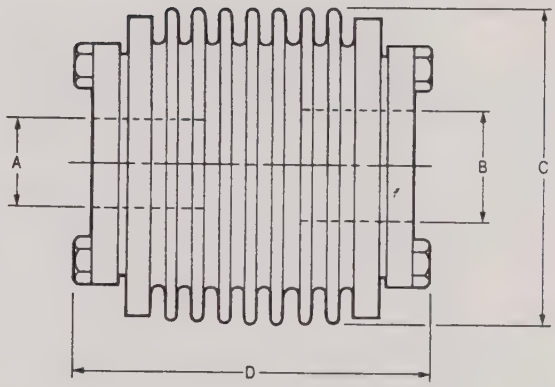
with the KH-series. Ask Your Compumotor salesman for a catalog or specification.

For unusual motor installations contact your Compumotor applications engineer for assistance.

Coupling Model No.
CPG2
CPG4
CPG8
CPG12



Coupling Model No.
CPG20
CPG30
CPG80
CPG170



Coupling Model No.	Motor Model	A Shaft Size inch	A Shaft Size mm	B Output Bore Dia inch	B Output Bore Dia mm	C Outer Dia inch	C Outer Dia mm	D Overall Length inch	D Overall Length mm	Inertia oz-in²	Inertia 10⁻⁶kgm²
CPG2-4	KS-210	0.276	7.000	0.250	6.350	0.984	25.000	1.654	42.000	0.252	4.600
CPG2-6				0.375	9.525	0.984	25.000	1.654	42.000	0.252	4.600
CPG4-4	KS-220	0.276	7.000	0.250	6.350	0.984	25.000	1.713	43.500	0.252	4.600
CPG4-6				0.375	9.525	0.984	25.000	1.713	43.500	0.252	4.600
CPG8-10	KS-230	0.551	14.000	0.625	15.875	1.575	40.000	2.343	59.500	2.187	40.000
CPG8-12				0.750	19.050	1.575	40.000	2.343	59.500	2.187	40.000
CPG8-10	KS-240	0.551	14.000	0.625	15.875	1.575	40.000	2.343	59.500	2.187	40.000
CPG8-12				0.750	19.050	1.575	40.000	2.343	595.00	2.187	40.000
CPG12-10	KS-250	0.748	19.000	0.625	15.875	1.575	40.000	2.441	62.000	2.187	40.000
CPG12-12				0.750	19.050	1.575	40.000	2.441	62.000	2.187	40.000
CPG20-10	KS-260	0.748	19.000	0.625	15.875	2.205	56.000	2.520	64.000	9.295	170.000
CPG20-12				0.750	19.050	2.205	56.000	2.520	64.000	9.295	170.000
CPG30-12	KH-710	0.748	19.000	0.750	19.050	2.598	66.000	2.795	71.000	16.402	300.000
CPG30-14				0.875	22.225	2.598	66.000	2.795	71.000	16.402	300.000
CPG80-14	KH-720	0.945	24.000	0.875	22.225	3.228	82.000	3.110	79.000	32.805	600.000
CPG80-16				1.000	25.400	3.228	82.000	3.110	79.000	32.805	600.000
CPG80-14	KH-730	0.945	24.000	0.875	22.225	3.228	82.000	3.110	79.000	32.805	600.000
CPG80-16				1.000	25.400	3.228	82.000	3.110	79.000	32.805	600.000
CPG170-14	KH-740	0.945	24.000	0.875	22.225	3.228	82.000	3.150	80.000	32.805	600.000
CPG170-16				1.000	25.400	3.228	82.000	3.150	80.000	32.805	600.000

WIRING

WARNING

Be certain that all AC power is disconnected before attempting to do any wiring. The wiring between the motor and Drive should be done with AC power disconnected as there are life threatening voltages on the motor when energized.

Motor Connections

The KH-Drive is supplied with a preassembled motor cable with an MS type connector on the motor end, and 4 leads with ring terminals on the drive end. This cable should be attached to both the motor and the drive before the AC power is connected. The motor connections on the KH-Series drive are made to a screw terminal block on the front panel. The terminals are marked as

DRIVE	MOTOR
A	A = ORANGE/ WHITE STRIPE
B	B = BLUE/WHITE STRIPE
C	C = GRAY /WHITE STRIPE
GND	GND = GREEN/WHITE STRIPE

The standard cable supplied with the KH-Drive is 25 feet in length. It is assumed that this cable will be run from the motor to a nearby terminal strip from the terminal strip your electrician would pull wire through a conduit to a second terminal strip inside the nema cabinet. From the second terminal strip inside the cabinet you can connect to the drive. The wire you use should be of 12 gauge or larger stranded wire for lengths up to 100 feet. Wire used by the factory is from Storm Products #sp3368 phone 408 749-9400. Lengths above 100 feet are not recommended. Due to the noise that is on the motor line and for safety reasons (320 volts) we recommend that the motor wiring be pulled through conduit. The motor power cable should not be in the same conduit with the resolver cable or the indexer logic cables.

If you wish to avoid the terminal strip at the motor end, Compumotor can provide cables with the MS connector in lengths up to 100 feet. They will need to be ordered as separate line items.

The KH-drive is configured to handle either delta or wye wound motors. Motor winding inductance must be at least 1 millihenry phase to phase. However you should be aware that the resolver feedback circuit is very specific. As such it is very unlikely that a motor/resolver combination from another source will operate properly with the KH drive.

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Resolver Connections

A preassembled 50 foot cable is supplied for connecting the resolver to the Drive. This cable has an MS style connector on the motor/resolver end and a 9-pin D type connector on the drive end. This cable is an important part of the resolver feedback circuit DO NOT CUT the resolver cable as this will affect the accuracy of the system.

The MS type connector should be connected to the motor mounted resolver connector and securely tightened. The 9-pin D connector should be connected to the mating resolver connector on the Drive and secured with the two captive mounting screws.

This cable is shielded to reduce noise in the resolver circuit. We do not recommend cutting this cable or the use of other than Factory supplied cable in the resolver circuit. The 9 pin D style connector can be pulled through a one inch conduit. You can order 100 foot resolver cables from the factory however the accuracy specification for the system may be degraded. If you choose to build your own cable resolver cable instead of a factory supplied cable: use shielded cable, foil wrapped twisted pairs and extreme care with respect to maintaining shield integrity. Even a small amount of noise getting into the resolver circuits can cause major performance problems. In addition the line capacitance affects the phase relationship of the resolver feedback system, this impacts the positional accuracy.

100 foot long cables are available on special order from the factory.

ms connector	color code	signal name	9 pin D
pin a	white	r1	pin 4
pin b	brown	r2	pin 9
pin c	blue	s4	pin 3
pin d	green	s2	pin 6
pin e	red	s1	pin 1
pin f	black	s3	pin 7
pin g	shield	shield	pin 5

Line Power Connections

AC power is connected to the screw terminal connector on the front panel. The 240 V.A.C. three phase power connection wire should be at least 12 gauge wire. The 120 V.A.C. Single phase should be connected with a 14 gauge or heavier, stranded wire. The wires should be connected to the screw terminals as follows:

120 VAC single-phase power, (100 V.low line, 130 V. high line, 50-60 HZ)

Terminal	NAME	Wire color
LINE	120 VAC LINE	Black (blue)
NEUT	120 VAC NEUT	White (brown)

240 VOLT A.C. THREE PHASE (200 V. low line, 250 V. high line, 50-60 HZ)

Terminal	Function	Wire color
PHASE 1	240 V PHASE A	BLACK (blue)
PHASE 2	240 V PHASE B	RED (brown)
PHASE 3	240 V PHASE C	WHITE (yellow)
GND	Earth ground	GREEN (green or green with yellow)

Either delta or wye connected grounds are ok. The 120 single phase may be developed from a step down of the 240 VAC or other means as long as the neutral is electrically connected to ground.

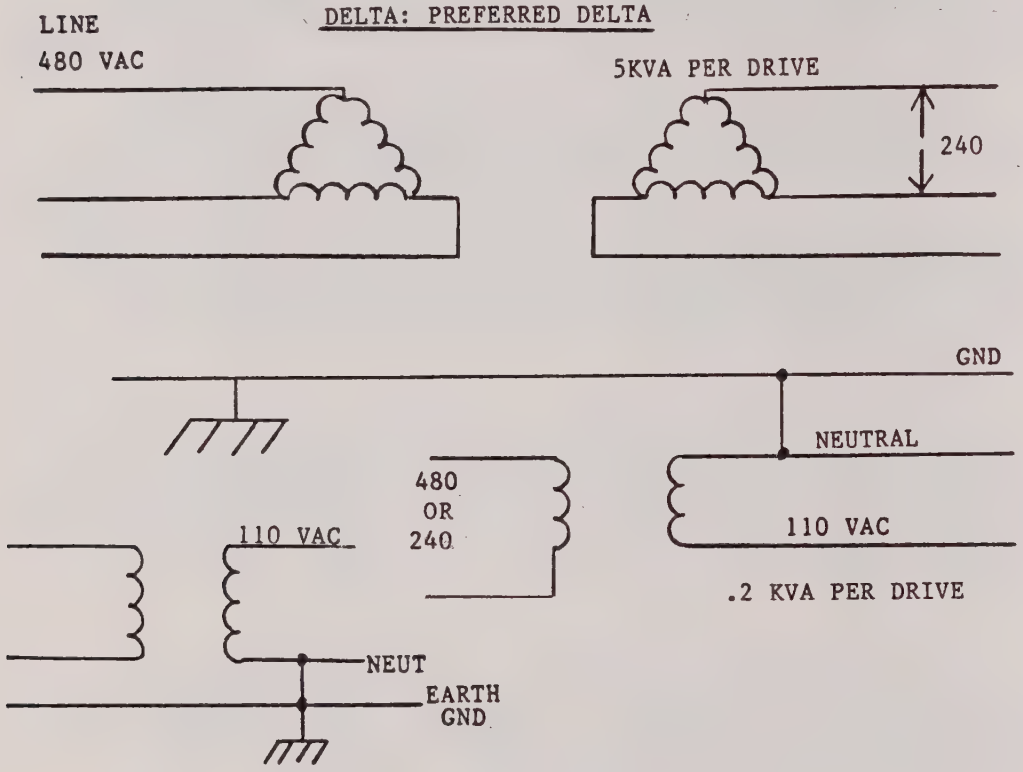
Be careful to ensure that the leads do not short to one another and there are no loose strands that are not captured by the terminal connection for each lead.

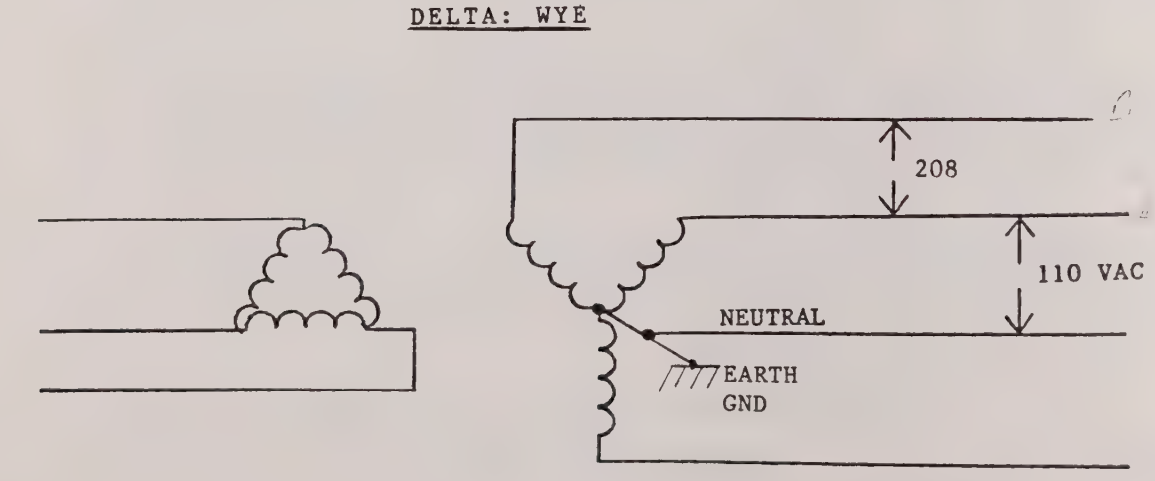
The KH-drive has a brownout protection circuit. If the AC power drops below the low line specification above the drive will shut itself down and will not run again until the line voltage is back to normal.

There is no protection against voltages exceeding 250 VAC. If the voltage exceeds the high line specification then there is risk that the drive will be destroyed.

NOTE: THE GROUND FOR THE 3 PHASE POWER MUST BE THE SAME AS THE GROUND FOR THE SINGLE PHASE POWER. If this is not the case a ground fault is possible that will not blow the fuses and may start a fire. Contact Compumotor for further details about configuring the KH-Drive for situations other than those

case a ground fault is possible that will not blow the fuses and may start a fire. Contact Compumotor for further details about configuring the KH-Drive for situations other than those provided for at the factory.





Line Power Considerations

The 120 VAC input to the Drive is not isolated by a transformer.You can provide Isolation by step down from a 480 or 240 VAC supply. Power to the KH-Drive should be routed through an isolation transformer with a power rating of 5 KVA.

An isolation transformer with line filtering capabilities will also insulate sensitive equipment on the same power line from the noise induced in the power line by the switchmode amplifiers in the KH-Drive.

> NOTE: THE GROUND FOR THE 3 PHASE POWER MUST BE THE SAME AS THE GROUND FOR THE SINGLE PHASE POWER. IF this is not the case a ground fault can occur which will not blow the fuses. This situation can CAUSE A FIRE.

Indexer Connections

The Indexer connector on the KH-Drive is a 25-pin D connector which is compatible with Indexer to Motor/Drive cables supplied with all Compumotor Indexers shipped after 02/22/85. If you purchased a Compumotor indexer product with your KH-drive, then all you need to do is plug in the supplied cables in order to have the indexer fully connected to the drive.

If you are supplying indexer signals from your own equipment,you must supply step and direction signals to the Drive. STEP+ and STEP- both must be connected to run the motor. DIRECTION+ and DIRECTION- need only be connected if the motor needs to be run bi-directionally. SHUTDOWN+ and SHUTDOWN- must be connected if the motor is to be shutdown remotely without powering down the drive.(see appendix A for pin outs)

The inputs to the drive are opto isolators that require a nominal 20 milliamps at 1.3 to 5 volts to turn on the opto LED. The step input requires a pulse at least 500 microseconds wide to create a single step on the servo. slower pulse rates can use a 50% duty cyle since the circuit is edge triggered.

The Direction and remote power shutdown are slower circuits and the current must flow for more than one millisecond to energize them. See the appendix for a diagram of the input circuit.

Auxilliary Connector Connections

The KH-Drive has two signals available on the auxilliary

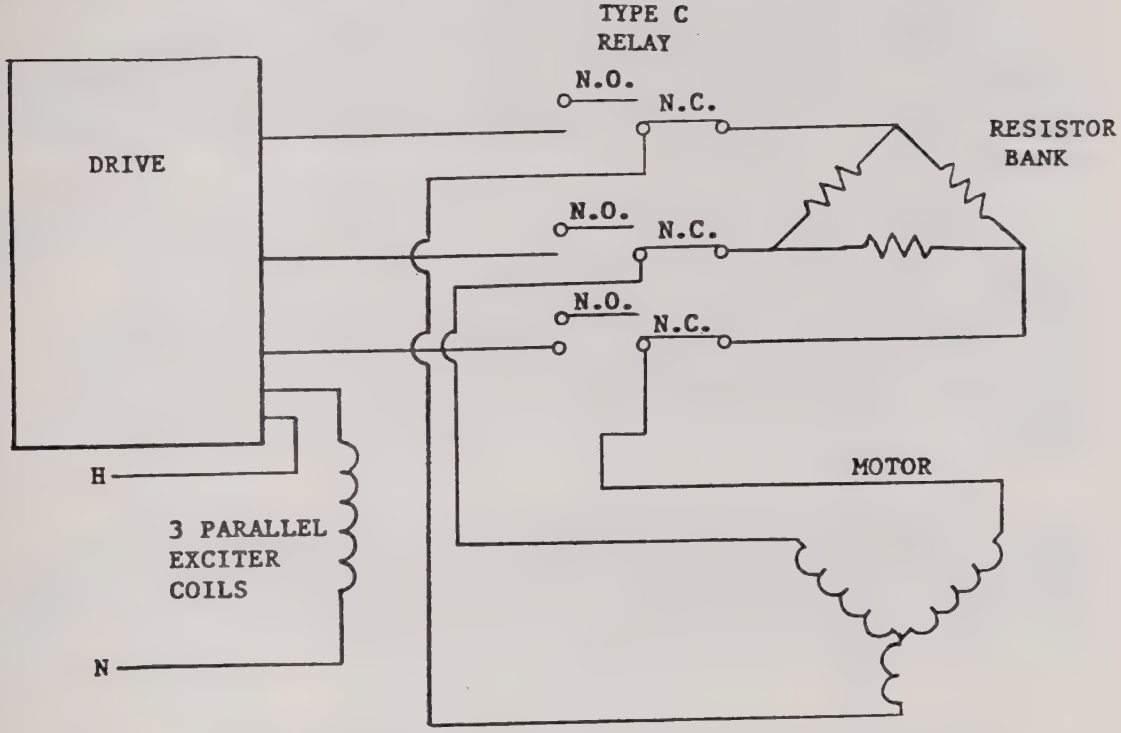
connector, DRIVE ENABLE and FAULT.(see appendix for pin outs)

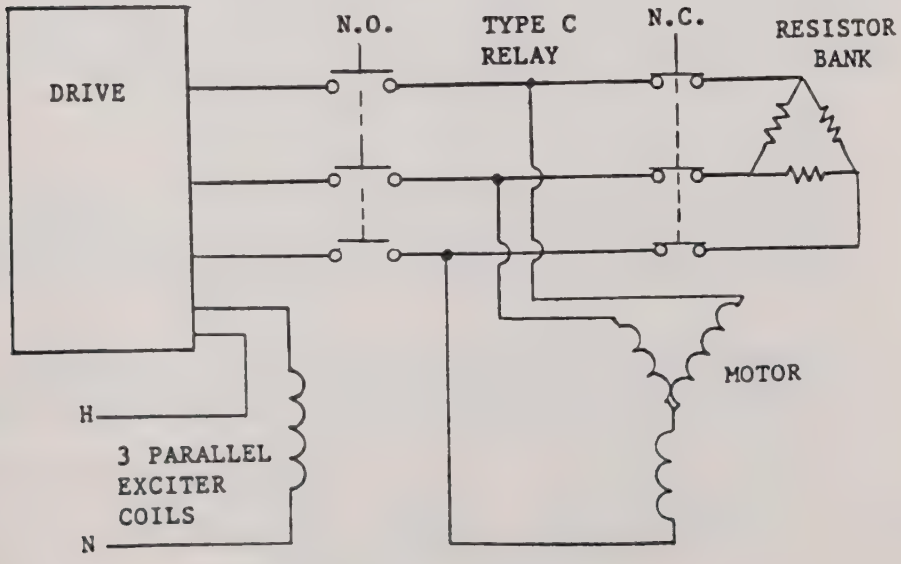
The DRIVE ENABLE is an optional input that can be connected to external devices to enable or disable the KH-Drive. If you desire hardwired end of travel switches that bypass the indexer this is where you would connect them. This input is shipped from the factory with a jumper to ground. If you wish to use it you will need to add normally closed switches to the circuit.

The FAULT output provides an indication of an overcurrent, overtemperature or shortcircuit condition in the amplifier section of the Drive. This output is identical in function to the DRIVE FAULT output on the indexer connector and the DRIVE FAULT LED indicator, except that it is not activated by shutdown commands for the drive on the indexer. This is an open collector device, with the collector tied to the FAULT terminal and the emitter tied to FAULT RETURN. It is capable of sinking up to 100 mA from a user supplied, 5 to 30 VDC source.

You may elect to use the fault output to drive a relay that switches dropping resistors into the motor circuit in the event of a drive fault. This would be a good thing to do if there were safety implications of the motor being able to freewheel in the event of power failure or other faults.

User supplied dynamic braking circuit option

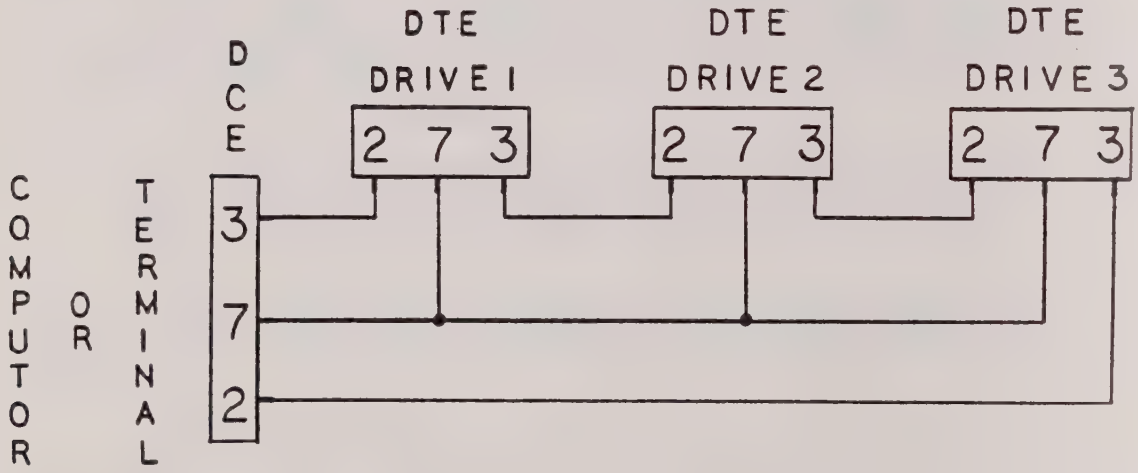




RS-232 Connector

The RS-232 connector is a standard 25-pin D connector and is electrically compatible with the IEEE specifications for RS-232C communications. The KH-Drive has a three wire implementation of this interface and provides RECEIVE DATA (pin 2), TRANSMIT DATA (pin 3), and GROUND (pin 7) signals on the connector. None of the other pins are connected.

The communication format is fixed at 9600 baud, 8 data bits, 1 stop bit, and no parity.



Fuses

240 V.A.C. FUSES

5AG TYPE BUSS FNQ 20 AMP, 20 Millisecond delay, 500 VOLT
13/32 x 1.5 inch

or as an alternative

5AG TYPE BUSS FNW 20 AMP, 20 Millisecond delay, 250 VOLT
13/32 x 1.5 inch

120 V.A.C. FUSES

3AG TYPE BUSS MDA-2 2 AMP, SLOW BLOW, 250 VOLT
1/4 x 1.25 inch

The fuses for the KH-drive are all accessible from the front of the drive the fuse holders are clearly identified on the panel. There are no fuses inside the drive.

OPERATION

General

The procedures outlined in this section are intended to help the user to quickly and safely begin operating the KH-Drive. Once you have completed the installation of the system and made the initial adjustments, there should be little or no adjustment required to maintain these drives.

Initial Start-up

Powering Up the System

To familiarize yourself with the operation of the system, you may wish to go through the start-up procedures before final installation of the motor to your load. If so, you should first attach the motor, resolver and indexer cables before applying AC power. Be careful to keep the motor shaft away from any cables or other loose objects which could get tangled when the shaft rotates. The motor should be firmly supported to prevent it from moving while it is running.

NOTE: DO NOT CYCLE THE AC POWER AT LESS THAN 1 MINUTE INTERVALS OR DRIVE FAILURE MAY OCCUR.

WARNING

Do not grab hold of the motor shaft while it is turning, since there are sharp surfaces on the shaft. Also be sure that if you have a shaft key that it is removed from the shaft because it could fly off when the motor is rotating.

Verify that all cables and wiring are properly connected, that the motor shaft is free from obstructions and then apply power to the system.

Visual Indicators

There are four LED indicators that are dedicated to single functions, they are:

MAX CURR: This LED is normally off.

The MAX CURRent LED is yellow if the user specified average current has been exceeded, or if the maximum allowable RMS current of the drive has been exceeded. This is usually due to a duty cycle that is too high. This can also occur if only two of the three motor phases are connected or working.

SHORT: This LED is normally off.

The SHORT LED is red if the drive detects a short in the motor circuit. This can be caused by mis-wiring, improper motor selection or defective motor. This error can only be cleared by turning the AC power off for at least 1 MINUTE and then powering back up again.
OVER-TEMP: This LED is normally off.

The OVER-TEMPerature LED will only be on when the thermostat in the drive is above safe operating temperature. Once the drive cools down this LED will turn off. Since the drive shuts itself down when over temperature condition is reached, the OVER-TEMP LED could be out by the time maintenance personnel reach the scene. In this event the error display code will need to be consulted.

REGEN-ACT:This LED is normally off.

The REGENeration circuit ACTive LED will blink on when the motor is generating power that is being dissipated in the power dump resistor. This is a normal function when the motor is decelerating or is being back driven by the load. This LED is an important diagnostic tool if the drive is going into overtemperature.

If this LED is on more than 10% of the time or for more than 10 seconds in duration, then the motor sizing and duty cycle calculations should be reconsidered. It may be necessary to add external resistors to the circuit to dissipate the power generated by the load and to add cooling facilities to the resistors, change motor sizes, change gear ratios, or slow down the duty cycle to prevent the drive from overheating in cases where the internal resistors are dissipating large amounts of energy from the motor.

NOTE: INITIAL IN RUSH CURRENTS ON POWER UP ARE LIMITED BY A THERMISTOR CIRCUIT AS SUCH THE DRIVE NEEDS ONE MINUTE OF COOL DOWN TIME BEFORE BEING POWERED UP AGAIN. DO NOT CYCLE THE POWER REPEATEDLY OR DRIVE FAILURE WILL OCCUR.

The STATUS LED will normally be green when the drive is properly powered up and running.

If the STATUS LED is red then the 110 VAC power at least is on but the microprocessor is not running.

The ERROR LED will be red only if there is a microprocessor detectable error condition.When the drive faults the error light will come on and the numerical display will show a numerical error code.

code	condition
11	over temperature
12	resolver signal lost/motor stall
18	240 VAC lost, 110 VAC ok.
19	short on motor circuit
20	following error exceeded
21	outside allowable deadband
22	maximum average current exceeded
23	enable circuit not connected
30	EEPROM checksum error
40	Both limits engaged and indexer commands attempting move.

Indexer Functions

Compumotor offers a variety of Indexers which are compatible with the KH-Drive. The 430, 1811, 1830 and 3000 indexers allow the user to specify velocity in steps per second. The 2100, 172 and 150 indexer require velocity to be specified in revolutions per second. unless you order software in these indexers for the 5000 step/rev option, the indexer will typically be set up for, 1 rps is equal to 25,000 steps per second. If you have and indexer set up for 25000 steps per rev you have several options. You can use the CMR command on the KH drive to set the servo up for 25000 steps per rev. You can order 5000 step per rev software for your indexer (proms). Or you can do some arithmetic to keep track of the speed yourself.

For example if you have the KH set up for 5000 steps per rev and the indexer set up for 25000 steps per rev. then the motor will run 5 times as fast as the indexer settings.

Performing a functional check using one of these indexers consists of the following steps:

1. Attach the motor/drive cable from the indexer to the KH-Drive.
2. Set up the Indexer in accordance with the Installation and Hookup section.
3. To verify that the KH-Drive is operating properly, apply power to the KH-Drive and set the indexer to perform a 5000 step/second constant velocity move. This will cause a 5000 steps per revolution motor to rotate at the rate of one revolution per second.

By increasing the velocity setting of the indexer and issuing a new START command you will increase the rotational velocity of the motor. The motor should be able to accept frequencies up to 5000 (PPR) X the maximum rated speed (RPS) of the motor you are using.

The direction of the motor can be changed by stopping the motor, changing the DIRECTION switch on the indexer, and issuing a new START command.

If you wish to make this functional check with a square wave generator or some other pulse source, the positive or "hot" lead of the square-wave generator should be attached to the STEP+ input on Drive. Refer to Appendix A for pin connections. Ground from the frequency generator should be attached to STEP-. The output of the square-wave generator should be set to 3 volts peak. There is an 220 ohm resistor and LED in series between the STEP+ and STEP- inputs. The current through these components should not exceed 30 mA for reliable operation.

Indexer Inputs and Outputs

The indexer inputs provide the normal control signals for the KH-Drive. Following is a functional description of how each is used.

Step Input

The STEP input causes the motor position to be incremented one unit of feedback resolution. The resolver feedback used on Drives is digitized to 32,768 parts per revolution. Optional resolutions of 1000 to 32,768 steps per revolution are programmable by using the CMR command. By applying STEPs at various rates the motor is made to rotate at proportional velocities. STEP pulses applied first slowly, and then more quickly have the effect of accelerating the motor. Attempting to accelerate the motor too quickly can cause the motor to lag behind the commanded position. There is an adjustable user defined value for maximum following error which will shut down the drive if exceeded. There is also a slip fault output to indicate if the motor is within the deadband specified or not.

Direction Input

The DIRECTION input controls the direction of rotation of the motor. When this signal is not activated the motor shaft rotates counter- clockwise as viewed from the flange end of the motor. The motor shaft rotates clockwise if the DIRECTION input is activated.

Remote Power Shutdown (RPS) Input

Activation of the REMOTE POWER SHUTDOWN (RPS) input causes the Drive to stop putting current through the motor. This will allow the motor to freewheel and as such is intended to allow manual positioning of the load or to keep the Drive from interfering with sensitive electronics in the immediate vicinity.

It is <u>not</u> intended to act as an emergency stop for the motor. If RPS is used in this fashion the motor will very likely move beyond its desired stopping position at the risk of **endangering property and life.**

Fault Reset Input

The FAULT RESET input will reset the microprocessor and clear an ERROR or DRIVE FAULT condition if the condition causing the fault has been removed.

Slip Fault Output

The SLIP FAULT output is activated whenever the actual position

of the motor is outside the user defined deadband. This output will be turned off when the absolute value of the following error is less than the deadband.

Drive Fault Output

The DRIVE FAULT output is activated when the amplifiers in the Drive are shut down for any reason. Faults originating in the amplifier are: over-temperature condition, over-current condition, and abnormal internal circuit operation condition. Faults originating in the controller are: shutdown, excess following error, and average current limit exceeded. Once the condition causing the fault has been cleared and the drive reset, normal operation may resume.

Auxilliary Inputs and Outputs

Drive Enable Input

The DRIVE ENABLE input can be used to enable or disable operation of the Drive. This input requires a normally closed connection from the input to the PULLUPS terminal.

Drive Fault Output

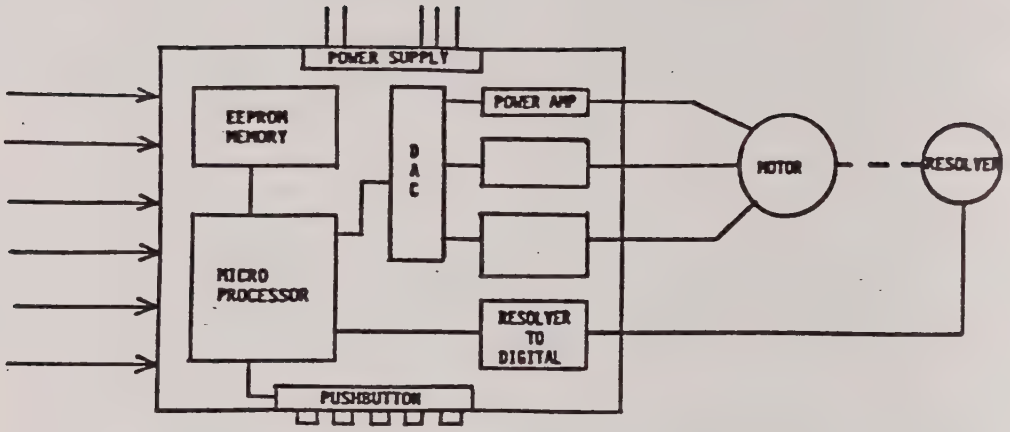
This output is identical to the DRIVE FAULT OUTPUT on the indexer connector, except that a "shutdown" command does not activate it.

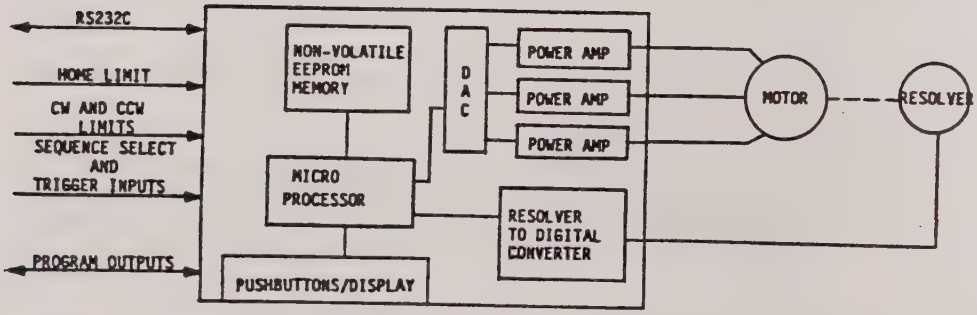
Set-up and Tuning

Introduction

The KH-Drive controller board is the "main brain" behind the drive's ability to position a servomotor. It performs ALL of the compensation necessary to stabilize the brushless servo system. No compensation is provided by the three amplifier boards. In fact, the amplifier boards are slaves to the controller board; the amplifier boards controls the current in the motor, the level of that current is commanded by the controller board.

A block diagram of the KH-Drive servo system appears below. The controller commands a "desired current" to the amplifier boards, the amplifier boards then attempt to generate that "desired current" in the motor's windings. The position of the motor's shaft is sensed by the controller via the resolver attached to the motor. This positional information is used by the controller to generate the "desired current" command to the amplifiers.


POWER SUPPLY
EEPROM MEMORY
D A C
POWER AMP
MOTOR
RESOLVER
MICRO PROCESSOR
RESOLVER TO DIGITAL
PUSHBUTTON


RS232C
HOME LIMIT
CW AND CCW LIMITS
SEQUENCE SELECT AND TRIGGER INPUTS
PROGRAM OUTPUTS
NON-VOLATILE EEPROM MEMORY
D A C
POWER AMP
POWER AMP
POWER AMP
MOTOR
RESOLVER
MICRO PROCESSOR
RESOLVER TO DIGITAL CONVERTER
PUSHBUTTONS/DISPLAY

The generation of the current command to the amplifier by the controller is based on several quantities, not just the position of the servomotor's shaft; it is based on a desired position, which is generated by an indexer, and on previous current commands to the amplifiers. An indexer generates a stream of pulses which the controller collects with an up/down (ie.clockwise/counterclockwise) counter. The resultant pulse count, at any given instant of time, is the desired position. The controller subtracts the motor's actual position from this desired position to determine the positional error. The positional error is the difference between where we want the motor to be and where it actually is. This positional error is put into an equation, along with previous positional errors and previous commands to the amplifier, to generate the current command for the amplifier.

The equation used by the controller to calculate the current command for the amplifier is known as a recursive equation. It is a mathematical equation, or function, that is evaluated at periodic time intervals. In the case of the KH-Drive controller the recursive equation is an approximation of an analog, continuous-time PID network. The analog, continuous-time PID is used quite often for the purpose of stabilizing conventional servo systems and consists of several potentiometers, resistors and capacitors. The KH-Drive's recursive equation is the discrete-time equivalent to a continuous-time PID network. It is called a discrete-time PID network because it operates on sampled data not on continuous data. The sampling-rate of the KH-Drive controller is the rate at which the recursive equation is evaluated and the rate at which the current command to the amplifier is changed. The sample-rate of the KH-Drive controller is 512 microseconds. By using such a very fast rate we can get excellent dynamic response.

The mathematical model for the tuning algorithm is based on the four values that you select plus the feedback from the resolver.

Once every 512 microseconds the resolver is read. this will provide position and velocity information. The desired position is compared to the actual position and an error value is generated. The error for the immediate time cycle is added to the error of the last 10 time cycles to produce the total following error.

Also the current velocity is calculated to be used in the following formula

$$\underset{\text{vel}}{\text{Cmds=Vel.}}\underset{\text{term}}{\left[\begin{array}{c}\text{(Integral x sum pos.)}+\text{Proportionalx(last)deriv.*(last - prev)}\\ \text{errors} \qquad\qquad \text{term} \qquad\qquad \text{pos err (pos error)}\end{array}\right]}$$

This means that the velocity term will change the responsiveness of the system.The Proportional term will affect the stiffness. The derivative term will affect settle time and dynamic response. The

Integral term will affect the final positional accuracy.

Tuning the KH-Drive Servo System

The most important aspect of a servo system is setting the controller's "gains". The controller in a conventional continuous-time (i.e., analog) servo system is an active or passive filter network, usually an op-amp with resistive and capacitive feedback. The values and configuration of the resistors and capacitors in the filter network are determined by the compensation necessary to stabilize the servo system.

The values of the resistors and capacitors can be thought of as being the "gains" of the controller. To stabilize the servo system it is necessary to adjust the gains (potentiometers) to match the system being controlled (the "system" being the motor, its load, and the amplifier). In the case of the KH-Drive the "gains" of the controller are the constant coefficients of the recursive equation (software). The form of the recursive equation determines how many of these "gains" must be adjusted in order to stabilize the system.

Fortunately, there are only four user changeable values in the equation and, better yet, it is not necessary to know the equation to tune an KH-Drive servo system. Tuning an KH-Drive servo system usually requires adjusting only one controller gain. The other gains are predefined and, in most cases, require no further adjustment by the user.

There are two methods available to adjust an KH-Drive's servo compensation network. The five pushbuttons on the KH -Drives front panel, and the RS-232 communications port.

Pushbutton Tuning

The K-Series drive has five pushbuttons on the front panel which provide a simple pushbutton method of fine tuning the systems performance to a specific attached load. The K-Series system is factory preset for typical user loads and for the individual motor supplied with the system. For many applications little or no adjustment is required by the user.

Once you have the system installed and the motor connected to its intended load, you can determine whether any fine tuning is required by observing the response of the system to commands from your indexer and by observing how "stiff" the system is when at rest.

With the motor at rest, try to deflect the shaft. You should not be able to easily turn the shaft away from its rest position. If it feels very soft, the system gains probably need to be increased. As

a very soft system will not respond very quickly to move commands. If the shaft feels stiff be certain to check that the system is not vibrating. If it is vibrating, the gain may be too high. This will cause the drive to provide excess current and can shorten the life of mechanical components. In extreme cases the vibration will grow in amplitude producing ever more violent motions until the drive faults or something breaks. For this reason tuning the KH-drive should be done with some caution.

On the front panel of the K-drive you will find five push buttons and a two digit display. The buttons are labeled UP, DOWN, P, I, V,. The button labeled P selects the PROPORTIONAL term in tuning the drive, The button labeled I selects the INTEGRAL term in tuning the drive and the Button labeled V selects the VELOCITY term in tuning the drive.

Select one of the P,I,V, buttons and hold it down. When you do the two digit display will light up to indicate the present value for the term you have selected. You should note this value in the event that you wish to return to it. While holding the button for the term you selected push the up button once and release it to increase the value of the term by one count. Push the down button once and release it to decrease the value of the term by one count. Repeated pushes on the up or down button will cause the term to continue to increase or decrease by one unit for each push of the button. You must hold the term button down while using the up and down buttons. If none of the term buttons are selected the display will not be lighted and no value changes will occur from the up and down.

If you need to change the value of the term by a large amount, simply hold the up or down button for a few seconds,holding the button down more than one second will cause the value to increment automatically. The value that will be used is the one displayed when you release the up or down button since the button is read by the microprocessor on the rising edge (button released). The value you have just selected will be used by the drive on the next move of the motor. This allows you to adjust the motor while you watch.

If you ever wish to retrieve the factory default values all you need to do is push both the P and I term buttons and release them at the same time, this will cause the factory values for each term to be reloaded.

For those of you that are familiar with the P I D form of tuning, you may change the D term by pushing both the I and V buttons and holding them both, while at the same time using the up and down buttons to change the value

In order to set a device address for the RS-232 port on the K-drive push the P and V buttons while you use the up and down buttons to

select a device address between 1 and 15. default address is number one.

After you have completed the pushbutton tuning procedure, or changing device address it will be necessary to save the values you have selected into non volatile EEPROM. This is done by pressing all three term buttons (P,I, & V) and releasing them. The act of releasing all three buttons will cause the values for all three terms to be saved.

Any software controlled drive faults can be reset by pushing both the up and down buttons and releasing them at the same time.

up	down	P	I	V	condition
0	0	0	0	0	display off/ unless error led is on
0	0	+	0	0	display current PROPORTIONAL value
+	0	+	0	0	increase PROPORTIONAL value
0	+	+	0	0	decrease PROPORTIONAL value
0	0	0	+	0	display current INTEGRAL value
+	0	0	+	0	increase INTEGRAL value
0	+	0	+	0	Decrease INTEGRAL value
0	0	0	0	+	display current VELOCITY value
+	0	0	0	+	increase VELOCITY value
0	+	0	0	+	decrease VELOCITY value
0	0	0	+	+	display current DIFFERENTIAL value
+	0	0	+	+	increase DIFFERENTIAL value
0	+	0	+	+	decrease DIFFERENTIAL value
0	0	+	0	+	display current device address
+	0	+	0	+	increase device address (max of15)
0	+	+	0	+	decrease device address (min of 1)
0	0	+	+	0	return to factory default
0	0	+	+	+	SAVE tuning values
+	+	0	0	0	RESET

other combinations are ignored.
+ = PUSHED 0 = NOT PUSHED

RS-232 Interface

The tuning process of the front panel switches can be duplicated via the RS-232 communication port. You may connect your computer or terminal to the RS-232 connector on the drive. The K series supports only transmit and receive lines. no handshaking is supported. The hardware implementation of the KH uses a TI 75152 chip, the KS uses a MC145406.

If the prompt that appears on your terminal is an asterisk (*)

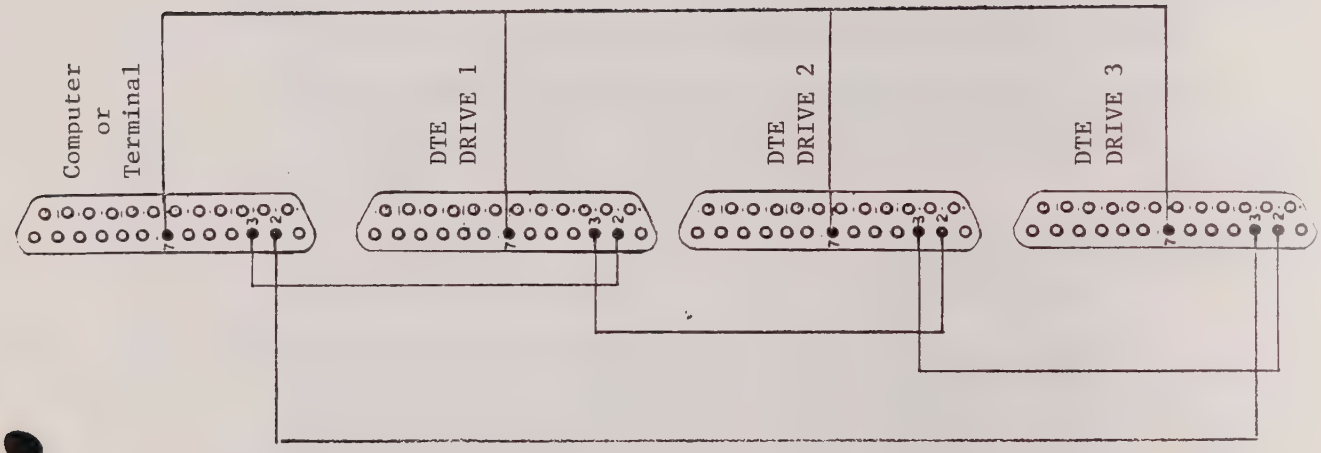
the K-Drive is ready to receive commands. If an asterisk does not appear on the terminal try issuing a few carriage returns. If this does not work, something must be wrong!! It is possible that some RS-232 communication parameters on the terminal are set incorrectly. The KH-Drive has only one setting for its RS-232 parameters -- 9600 baud, no parity and one stop bit. The drive is set up as a DCE.

On the RS-232 connector pins 2,3, and 7 are the only ones used. If you have more than one drive connected to a single terminal it is necessary to construct a daisy chain cable as shown here.

9600 BAUD

NO PARITY

2 STOP BITS



You may tune the drive from the RS-232 or the Push buttons but not at the same time. Using the E command will enable the RS-232 link and disable the push buttons (except the reset function). The F command will return tuning control to the pushbuttons.

GENERAL PURPOSE COMMANDS

All of the commands may be prefixed with a device address. Any command that will cause the drive to transmit information to the RS-232 port MUST be prefixed with a device address. This is to prevent several units from transmitting at the same time.

Responses and reports from the drive will have a * as a leading character to prevent the response from being interpreted as a command by other drives on the communication link.

Invalid commands will be ignored by the drive.

You may send either upper or lower case characters to the K drive, However the Echoed characters from the drive will always be Upper case. Thus in practice it is best to use Upper case to avoid confusion.

GENERAL COMMANDS

****

E — Enable the RS-232.

NOTE: IF YOU DO NOT GET ANY RESPONSE ON THE RS-232 LINK YOU PROBABLY DID NOT ISSUE THE E COMMAND.

The E command may be preceded by a device address 1 to 15, for example 1E will enable only device number one. Sending an E without a device address will enable all of the RS-232 ports on all of the drives on the daisy chain at the same time.

Enabling the RS-232 tuning function will disable the pushbutton tuning. (except the reset function).

SV
SAVE — Save new values.

This is the same as pushing all three mode buttons down and releasing them. The "SV" command will cause the controller to save the gains as they are now adjusted and exit the tuning process, meaning the tuning mode will be exited.

The save command will save any new values you have given the drive. For those values that were not changed the last value to have been saved will be resaved.

F — Exit the RS-232 mode and return to front panel control.

The F command will return control to the front panel pushbuttons. Any changes that have been made to the controller's gains are retained in volatile memory. However if a Save command is not issued the values will be lost on the next power loss or reset.

OFF
ST0 Turns the power amplifier off.

No current flows through the motor. AC power to the amplifier remains on.

ON
ST1 Turns the power amplifier on.

Allows current to flow through the motor.

RFS

Returns the drive to factory settings.

All settings are as they were when the drive was shipped from the factory. This is the same as pushing the P and I buttons at the same time.

HELP Returns help menu

Provides a list of commands and a brief description of each command.

ESCAPE
KEY When you are in the help menu the escape key will take you to the out of the menu.

RSE Reports servo errors.

If an error condition in the servo drive exists, such as excessive following error or an EEPROM failure, it will be reported. Errors are "soft errors" that are indicated with the ERROR LED and display codes. To clear an error one must reset the machine.

Z Resets the drive.

The drive will act as if power was cycled. This command implements a software reset of the system. Any changes that have not been saved before issuing this command will be lost.

RV — Software Revision level reported.

This command is for determining the software revision level of the controller software. It will report the part number that is written on the label of the controller's EPROMs. Using this command means it is not necessary to open the Drive amplifier's box in order to determine the revision level of the software.

KILL
K
STOP
S — STOP POWERING THE MOTOR

Issuing this command will cause the microprocessor to stop putting power to the motor until the reset command is received. All pulses/ position etc will be lost. These commands remove power from the amplifier and allow the motor to freewheel. These commands were added so that if during the tuning procedure over the RS-232 link the user makes the servo go unstable he has some means of stopping the system. This will normally be a panic situation so the commands were selected to be those most likely to be selected in this situation. The commands function exactly the same as the STO command.

It should be noted that in the KX versions the S and Stop commands are controlled be the acceleration settings. So the function of these commands change between the indexer and non indexer versions.

CONFIGURATION COMMANDS

****

The following configuration commands are designed to let you the user set up the system to meet your requirements. Normally the factory settings for the motor driver combination are all that you would need. However to allow for your special situation we have added the following commands. In the event that you have to replace a motor the first command that you would execute is the CMTR if and only if you have changed the type of motor that the drive was origionally set up for. After the drive is properly set up for the motor size, The FMCA command will find the commutation points of the motor/resolver combination for the particular motor you have. This is seldom a requirement but it is necessary before any of the other commands can be expected to execute in a normal fashion. CAUTION THE FMCA COMMAND CAUSES MOTION, SEE COMMAND LIST.

The next command to be needed will be the CMR command. This selects the motor resolution that you desire to work with. The motor resolution will affect any command or report that is in motor steps. Therefore you should choose the motor resolution before you do much else.

CMTR Configure/report Motor type

Use this command to configure the drive to the motor size that is being used with the drive. Normally this is done for you at Compumotor's factory. This command selects the proper current values and factory defaults for the various motor sizes used with the drive. The possible configurations are:

1CMTR This will report the present set up as *CMTR710

1CMTR710 Sets the drive up for the KH710 motor
1CMTR720 Sets the drive up for the KH720 motor
1CMTR730 Sets the drive up for the KH730 motor
1CMTR740 Sets the drive up for the KH740 motor

like the FMCA command it is not necessary to do a save after issuing a CMTR command with a parameter as it will automatically save the new motor type when the command is issued.

FMCA find motor commutation angle

Use this command if a new motor is being used or if a new resolver has been mounted on the motor, or if a resolver has been re-mounted on the motor. The use of this command is highly unusual, it will cause the motor to rotate under program control in the drive. **WHILE IT IS ROTATING THE USER HAS NO CONTROL OVER THE MOTOR. ONCE YOU START THIS SEQUENCE OF EVENTS YOU WILL HAVE TO CUT OFF THE AC POWER IF YOU WISH TO STOP THE MOTOR BEFORE THE COMMUTATION PROCEDURE IS COMPLETED.** For safety reasons you would normally find the computation angle with the motor disconnected from the load. It is not necessary to save after a this command as the offsets are automatically saved.

CMR configure motor resolution definition/report
numeric parameter expected (1000 to 32,768*)

Define/report motor resolution. Enter a number between 1000 and the maximum allowable resolution for the particular motor size (32,768, 16,384, or 8,192 depending on resolver configuration) the value entered represents the number of steps of resolution you want the resolver reading to have per revolution of the motor. If you choose a binary value the positioning will be slightly more accurate than a non binary value will provide. The math is done as an interger value so truncation error within a single revolution can occur. This error is not cumulative.

If a valid integer number is sent then the new resolution will be that number of steps per motor revolution. If no value is sent then the

current resolution is reported. Factory Default is 5000 steps per revolution.

The motor actually functions at 32,768 steps per rev in all cases. So changing the motor resolution does not affect dynamic performance. The microprocessor simply converts the number of incoming indexer pulses to the appropriate absolute resolver position mathematically. Thus a binary number converts to an exact resolver position, whereas a non binary number may be rounded off for a given position. However since the KH converts the absolute indexer count into the position there is no accumulation of error.

Since a change in resolution could cause major dynamic discontinuities the motor resolution can not be changed while the system is active. You must issue the STO command to disable the drive before you can change the motor resolution.

Be certain to save any changes you wish to retain before cycling power to the drive. NOTE:THIS COMMAND CHANGES THE VALUES AND RESPONSES OF ANY OTHER COMMAND THAT USES MOTOR STEPS. YOU SHOULD CONFIGURE MOTOR RESOLUTION BEFORE USING ANY OF THE OTHER CONFIGURE COMMANDS.

CCA configure current, average, limit- Definition/report.
Numeric parameter expected.(0 to 20.000 Amps)

If no parameter is supplied this command will report the currently defined maximum allowed average current, in amps. If a parameter is supplied that number will be used as the new maximum average current. The controller continuously computes an average current to the amplifiers over a 16.67 second time span. If the average current command exceeds the value defined by the this command the controller will disable the amplifiers and indicate an error. The factory default setting is motor dependant.

CCP configure peak current definition/report.
Numeric parameter expected.(0 to 40.000 Amps)

Define/report the peak current limit. This number defines the maximum current command that will be sent to the motor. This command is included for diagnostic and other special purposes. If a valid number in Amperes is entered, it will become the new peak current limit.If no value is sent this command will report the present value defined for the maximum peak current, in amps. The maximum current is the absolute maximum current that will be sent to the motor, it is not the maximum average current command but the maximum transient current. It is the

upper limit of how large the current can ever be. The Factory setting will depend upon the motor size. The value to determine if the limit has been exceeded is calculated in the same manner as the DCP command

CDB configure DeadBand definition/report.
Numeric parameter expected.(0 to 32,767)

If no parameter is supplied this command will report the current value of the deadband, in motor steps. If a number is supplied that number becomes the new deadband. The slip fault line to the indexer is used to indicate when the absolute value of the following error is within the deadband region. The slip fault line to the indexer connector will be on to indicate that the following error exceeds the deadband and off to indicate that the absolute value of the following error is within the deadband. (The slip fault line is active high). The default factory setting is zero. This is useful in situations when you need to know if the motor rotor is within a certain tolerance range with respect to the indexer command. If you wish to use this output to an external computer, you will need to connect wires from pin 10 and pin 22 of the indexer connector on the KH to your computer.

CPE configure position error definition/report
Numeric parameter expected (0 to 65,535 Steps)

Define/report maximum following error. If the position error is greater than this number, the amplifier will shut itself off. If a valid number in steps is entered, it will become the new maximum following error. Otherwise, the current setting is reported. Exceeding the maximum following error is an error condition that will cause the amplifier to be shutdown. If the maximum following error is defined as zero the "shutdown motor on following error exceeded" function is disabled and no amount of following error will generate an error condition or shutdown the motor. The factory default setting is one revolution of the motor. If you configure the motor resolution (CMR command) the default value will become the number of steps to make one motor revolution. If you send the CFE command with a valid number (0 - 32,767) then the new value will become the number of motor steps. Further changes of motor resolution from the CMR command will not change the following error to match the changes in motor resolution. E.G. The number you provided will remain the number of motor steps even if the step size changes.

This command differs from the CDB command in that being outside deadband only affects the slip fault output. The CPE settings will shut off the drive.

You should be certain to save your settings to the EEPROM if you wish it to be permanent.

TUNING COMMANDS

****

The following tuning commands are accessed via pushbutton tuning or the RS-232 communication link. The values represent a percentage of the maximum value that the term is allowed to achieve. The following commands change the percentage only and the range is limited from 1 to 99.To change the maximum value of the term it is necessary to use the configuration maximum commands. push buttons allow only integer values of the percentage. The display will show only the integer.

the form of the equation for the tuning set up is:
Gain value = term maximum x term percentage

CVG configure velocity gain definition/report.
numerical parameter expected (0 to 99)

The velocity gain is related to the error in the motor speed with respect to the commanded velocity from the indexer. If a valid numerical parameter is enter then the Velocity gain will be recalculated using the new percentage of the maximum. Otherwise, the current setting will be reported.

CDG configure differential gain definition/report.
numerical parameter expected (0 to 99)

The differential gain is related to position error changes with respect to time. If a valid number is entered, a new differential gain will be calculated using the percentage of the maximum. Otherwise, the current setting is reported.

CIG configure integral gain definition/ report.
numerical parameter expected (0 to 99)

The integral gain is related to position error with respect to time. If a valid number is entered, a new integral gain will be calculated using the percentage. Otherwise, the current setting is reported.

CPG configure proportional gain Definition/report.
numerical parameter expected (0 to 99)

The proportional gain is related to the position error. If a valid number is entered, a new proportional gain will be calculated based on the percentage. Otherwise, the current setting is reported.

CONFIGURE TERM MAXIMUMS
****

The following tuning commands are accessed only via the RS-232

communication link. The values:

CVM configure velocity maximum. Definition/report.
numerical parameter expected (1 to 32767)

This command allow you to change the factory value for the Maximum gain that the Velocity term can achieve. This would normally be changed only if the values provided for your motor were not satisfactory for your application.The default values are motor dependant. If a valid parameter is sent that value will become the new maximum, otherwise the current setting is reported.

CDM configure differential maximum Definition/report.
numerical parameter expected (1 to 32767)

This is the gain of the portion of the controller which amplifies the derivative of the position error with respect to time. If a valid number is entered, it will become the new differential gain maximum. Otherwise, the current setting is reported.

CIM configure integral maximum Definition/report.
numerical parameter expected (1 to 32767)

Defines the maximum of the integral of the position error with respect to time. If a valid number is entered, it will become the new integral gain maximum. Otherwise, the current setting is reported.

CPM configure proportional maximum Definition/report.
numerical parameter expected (1 to 32767)

Defines the maximum of the term which amplifies the position error. If a valid number is entered, it will become the new proportional gain maximum. Otherwise, the current setting is reported.

NOTES:

If you supply an invalid parameter to a command the command will not be performed invalid commands are simply ignored and thrown away.

Any changes made to parameters using these commands are NOT permanent UNTIL THEY ARE SAVED. To make a change permanent the SAVE command (SV) must be issued. The SAVE command will save all changes that have been made into the EEPROM. Thus, if changes are made with these commands and then the machine is reset the changes are lost unless the SAVE command was issued before resetting the machine.

DISPLAY/REPORT COMMANDS
****

Each of the display/report commands results in the drive

periodically reporting the appropriate parameter to the terminal where it is displayed Approximately every 130 milliseconds as the value is reported to the terminal. When any of these commands is issued no other command may be issued until the reporting is terminated. To terminate a report hit any key to send a character to the drive. All display report commands must be prefixed with a device address. This is to prevent several units from trying to report at once. These commands do NOT display values to the two number display on the pushbutton tuning panel.

DCA periodically displays/reports current (average) in Amperes.

The average current flowing through the motor is reported and repeatedly updated until a key is pressed. To get this number 128 data points of the peak instantaneous current are read at 512 microsecond intervals. These 128 points are averaged to provide a value computed at 65 millisecond intervals. This value is averaged with the last 256 similar values to provide the average current over the last 16.67 seconds. The new average current is reported on every other calculation to be displayed at 130 millisecond intervals.

DCI periodically displays/reports current on and instantaneous basis

This number is reported in Amperes and is repeatedly updated until a key is pressed This number is a single sampling of the current at read and reported at a 128 millisecond rate.

DCP periodically displays/reports the peak current

This number is reported in Amperes and is repeatedly updated until a key is pressed. This command samples the instantaneous current at 500 microsecond intervals. Each reading is compared to the largest previous reading, if the new value is larger then it will become the new value. This value is reported at 128 millisecond intervals. This reading accumulates from the time the command is sent. so that the highest instantaneous current ever seen by the motor over long periods of time may be captured.

DPA Periodically displays/reports the actual position.

This number is reported in steps and is repeatedly updated until a key is pressed. This number is the absolute resolver position in motor steps since the drive was enabled. The value is read and reported at 128 millisecond intervals

DPE periodically displays/reports position error.

This command reports the difference between setpoint and actual position in steps. This number is used by the position control

algorithm to determine what sort of current should be sent to the motor.The difference between the command setpoint and the actual position is also used to determine if the motor is within the Deadband specified in the CDB command. This number is reported in motor steps and is repeatedly updated until a key is pressed. This number is a single instantaneous value read and reported at 128 millisecond intervals.

DPR Periodically displays/reports the resolver position.

This number is reported in steps and is repeatedly updated until a key is pressed.This value is the resolver position in motor steps within a single revolution of the motor shaft. This is an absolute value with the zero referenced to how the resolver is mounted on the shaft. This data would be useful to diagnose a resolver problem. This number is a single data point read and displayed at 128 millisecond intervals

DPS Periodically displays/reports the position setpoint

This number is reported in steps and is repeatedly updated until a key is pressed. This number is the absolute number of pulses sent to the drive from the indexer since the drive was enabled. this counter is read and reported at a 128 millisecond rate.

DIC Periodically displays/reports indexer counter

Periodically reports the contents of the indexer counter in steps. This number is reported and repeatedly updated until a key is pressed. This is the raw number of pulses sent to the drive from the indexer. It may differ from the setpoint in that the Indexer may have sent pulses to the drive when it was no enabled. This command is a quick way to check out the indexer to drive interface. The counter is read and reported at a 128 millisecond rate.

DVA Periodically displays/reports velocity actual.

This number is reported in steps per second and is repeatedly updated until a key is pressed. This number is calculated by taking 128 data points at 500 microsecond intervals. The average of the 128 points is reported at 128 millisecond intervals. This value is the actual velocity being read from the resolver.

DVS Periodically displays/reports the velocity setpoint

This number is reported in steps per second and is repeatedly updated until a key is pressed.This number is calculated by taking 128 data points at 500 microsecond intervals. The average of the 128 points is calculated and reported at 128 millisecond intervals. This value is the velocity being sent to the drive from the indexer.

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PID & V tuning

PID and V (proportional, Integral, differential and velocity) tuning algorithm can be implemented with the pushbutton tuning the factory values of the tuning algorithm are based on the assumption of load to rotor inertia of 10 to 1. or less, that the load is pure inertia, that it is directly and solidly coupled to the motor and that a 4% overshoot is tolerable. If your system can not be tuned with the pushbuttons then the load to rotor inertia may be outside of the range provided for using the factory settings, there is a significant amount of friction in the system, the coupling to the load is flexible. In situations like this you are faced with a complex series of tradeoff decisions. As with every other physical system you can't get something for nothing. You can increase the speed of your machine at the price of motor/drive heating, final position accuracy and settling time. Or you can improve system accuracy at the price of final position stability. You can trade final positional accuracy for system response time. Each application requires you the user to decide which of the variables will be traded to optimize performance in your situation.

A generalization of the functions of the PID gains are:

PROPORTIONAL GAIN affects the system stiffness and accuracy. As the proportional gain is adjusted higher, the influence of the feedback signal becomes greater. If the gain is sufficiently high, the system will oscillate. This happens because very small resolver changes are amplified into very large error signals, and the mechanical inertial of the motor and load will not allow the system to follow the electronic commands fast enough. The systems lag time will eventually reach a point where the feedback and the command signals are in phase. At this point oscillation results. When this occurs you have no choice except to reduce the gain back below the oscillation point.

INTEGRAL GAIN gives the system compensates for disturbances of static position. (Frictional type errors). The integrator also works to reduce velocity ripple. It does this by slowing down the electronic response time so that it more closely resembles the response of the mechanical components of the loop.

DERIVATIVE GAIN adds damping effects to the system. In the case where the system is oscillating at the end of a move or around a change in velocity increasing the derivative gain will reduce the ringing. The derivative adds phase lead to compensate for the systems natural phase lag.

VELOCITY GAIN this gain is used to affect the overall responsiveness of the system. If the system is too sluggish then the velocity gain can be increased. If the system is overshooting badly or there is excessive ringing that the derivative term is not able to

adequately compensate, reduce the velocity gain.

Position errors due to Load inertia.

Load is the inertia (mass times the radius of rotation squared)seen by the shaft of the motor, measured in Oz.-In. sec2. The amount of inertia affects the torque required, and the torque required is a function of acceleration and inertia.If you find that your load inertia is larger that 10 times the motor inertia you may find it desireable to trade some speed performance for accuracy at the final position. In this case to make the tradeoff you reduce the velocity gain and increase the Integral gain.

Slow response due to Load inertia.

In a system where the load inertia is larger than the factory setting allow for it may be possible to increase the system response time by allowing the overshoot to increase. In this case increase the Velocity gain, increase the proportional gain and decrease the Integral gain.

Position Errors Due to Friction

Significant friction in the load may cause the end-of-move position to be unacceptably in error. In this case you can trade off system response for final positional accuracy. To do this increase the integral gain, increase the derivative gain and if necessary decrease proportional or velocity gains.

Shaft and Coupling Vibration

If the load is coupled to the shaft through a non-rigid coupler, it is possible for the shaft and coupler to oscillate at a frequency greater than would be possible for the system as a whole. In this case it may be possible to trade system response for system stability. To do this increase the integral and derivative gains while decreasing velocity or proportional gains.

Inadequate Response Time (Frequency Response)

Some systems may involve very little inertia, but need the torque for very high acceleration. In this case it may be desireable to narrow the range of values that the system can handle in order to optimize the move profile for a light load. To do this increase the proportional and velocity gains while decreasing the integral term.

General tuning considerations.

You should remember that all of the terms are interactive and it may take considerable experimentation to find the exact combination of values to get the best performance in your application.
In a very general sense the velocity term should be set first, followed by proportional then integral and finally the differential terms.

Motor Compatibility

The KH-Drive is designed to be compatible with at least the following motor sizes:

Model number
KH710
KH720
KH730
KH740

For motors other than those listed above consult Compumotor for information regarding available options.

MAINTENANCE AND TROUBLESHOOTING

1. Motor Maintenance

All mechanical parts of the motor should be inspected regularly to ensure that no bolts or couplings have worked loose during normal operation. This can prevent some minor problems from developing into anything more serious.

2. Diagnostic LED's

STATUS -- This is a bi-color LED which will be green under normal operating conditions. If this LED is red it indicates a microprocessor failure. Cycling power to the drive will clear this condition only if it is temporary. If the LED remains red the unit should be returned for repair. If the unit powers up and the LED is green, the KH-Drive should be ready for operation again. Intermittent occurrences of a red STATUS LED can often signify electrical noise interference. See the System Installation Recommendations section of this manual for recommended noise suppression devices. If this LED is off it indicates a loss of the low voltage power supply. Check for correct input voltages and for fuses blown. If everything checks out and the drive is still not operating or if fuses blow when power is reapplied, send the unit back for repair.

FAULT -- This red LED will be off under normal operating conditions. It will be red if the amplifier section of the drive is shutdown. The amplifier will shutdown itself if an over-current, short-circuit or over-temperature condition exists. This LED will also be lit if the amplifier is shutdown by the Remote Power Shutdown input or if the microprocessor shuts down the amplifier because the ERROR LED is on. If this LED comes on, first try disconnecting the indexer cable. If the LED goes off, it was probably caused by a Remote Power Shutdown. If it stays on, remove power and examine the connections to the motor to verify that no short circuits exist in the wiring or motor, winding to winding or winding to ground.

ERROR -- This LED is normally off and glows red when the microprocessor detects an error condition such as excess following error or exceeding the average current definition. These error conditions will cause the microprocessor to shut down the amplifiers, which will also cause the FAULT LED to go on. The error code will be displayed on the two digit display or the RSE command can be issued to determine what condition(s) exist. The error condition can be cleared by resetting the drive, either by issuing a Z command, or by pushing both the up and down buttons at the same time or by cycling power or through the FAULT RESET input on the indexer connector.

SPECIFICATIONS

System dependent:

DESCRIPTION	VALUE	UNITS
Repeatability	+/- 0.088	degrees, unloaded.
Accuracy	+/- 0.23	degrees, unloaded.
Relative Accuracy	+/- 0.088	degrees, any load.
Driver Operating Temperature	0 to +50	degrees Celsius.
Motor Operating Temperature	130	degrees Celsius, max.
Storage Temperature	-40 to +85	degrees Celsius.
Humidity	0 to 95	percent, non-condensing.

Motor dependent:
(See torque speed curves)

DESCRIPTION	KH710	KH720	KH730	KH740	UNITS
Static Torque (cont.)	1034	2068	3399	4107	ounce-inches
Static Torque (peak)	2000	4000	6000	8000	ounce-inches
Top Speed revolutions/MINUTE	6000	2300	1450	1200	
Rotor Inertia	26.3	114.8	166.7	210.5	ounce-inches^2
Maximum radial load					pounds
Motor Weight	18.7	36.3	47.3	58.3	pounds
Total Shipping Weight	65.7	83.3	94.3	105.3	pounds

Physical Description

Drive Height: 16.75 INCHES (425mm)
Drive Width: 7.75 INCHES (197mm)
Drive Depth: 11.31 INCHES (287mm)

Drive Weight: 32 lbs (14.6kg)

Environmental

Operating temperature: 32°F to 122°F (0°C to 50°C) With adequate air flow
Humidity: 0-95%, non-condensing.

Electrical

Input power:
control circuit
Voltage: 100-130 VAC, single phase.
Frequency: 47-66 Hz.
Current: 5 amps maximum continuous (RMS).

motor circuit
Voltage: 200-250 VAC, three phase.
Frequency: 47-66 Hz.
Current: 20 amps maximum continuous (RMS).
40 amps peak

Output power: (to motor)
Voltage: 325 VDC peak
Frequency: 8 kHZ PWM
Current: 20.0 amps continuous per phase.
40.0 amps per phase peak.
@50 degrees centigrade

Inputs and Outputs

Indexer: 25 pin 'D' connector, female

1 **STEP+** Input. Optically isolated current loop input. 15 mA, 500 nS pulse, minimum; 1 MHZ maximum. Rising edge of current pulse causes one step.

14 **STEP-** Input. Return for Step+.

2 **DIRECTION+** Input. Optically isolated current loop input. 20 mA nominal. Must be held active at least 10 microseconds prior to rising current edge of STEP+.

15 **DIRECTION-** Input. Return for STEP+.

16 **RPS+** Input. Optically isolated current loop input. 20 mA nominal. Presence of current on RPS (Remote Power Shutdown) causes current to be removed from the motor phase outputs.

17 **RPS-** Input. Return for RPS+.

10 **SLIP FAULT+** Output. 20 mA nominal current output. Presence of current indicates that the motor is not within the user definable deadband range.

22 **SLIP FAULT-** Output. Return for SLIP FAULT+.

9 **DRIVE FAULT+** Output. 20 mA nominal current output. Presence of current indicates a drive fault condition. (Shorted outputs, overtemperature, etc...)

21 **DRIVE FAULT-** Output. Return for DRIVE FAULT+.

7 **FAULT RESET+** Input. Optically isolated current loop input. 20 mA maximum. Presence of current clears a DRIVE FAULT or an ERROR.

19 **FAULT RESET-** Input. Return for FAULT RESET+.

12 **COMMON** Low voltage power supply common.

RS-232: 25 pin D connector

2 **RECEIVE DATA** Input. RS-232 characters are received on this input. Conforms to IEEE standards for RS-232 communication.

3 **TRANSMIT DATA** Output. Characters received are echoed on this output. Conforms to IEEE specifications for RS-232 communication.

7 **COMMON** Output. This is the signal common for TRANSMIT and RECEIVE signals.

Auxiliary: 4 pin Entrelec Connector

1 **DRIVE FAULT+** Output. 20 mA nominal current output. Presence of current indicates a drive fault condition. (Shorted outputs, overtemperature, etc...)

2 **DRIVE FAULT-** Output. Return for DRIVE FAULT+.

3 **DRIVE ENABLE-** Input. Return for DRIVE ENABLE.

4 **DRIVE ENABLE+** Input. Optically isolated current loop input. 20 mA maximum. Presence of current enables drive.

APPENDIX A

CONNECTOR LISTING

A. Motor Connections

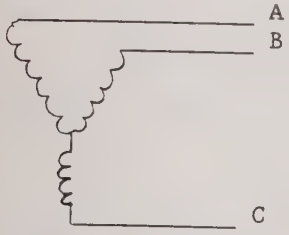
The KH-Drive is supplied with a preassembled motor cable with an MS type connector on the motor end; and 4 leads with ring terminals on the drive end. This cable should be attached to both the motor and the drive before the AC power is connected. The motor connections on the KH-Series drive are made to a screw terminal block on the front panel. The terminals are marked as

A	MOTOR	A = ORANGE/ WHITE STRIPE
B		B = BLUE/WHITE STRIPE
C		C = GRAY /WHITE STRIPE
GND		GND = GREEN/WHITE STRIPE

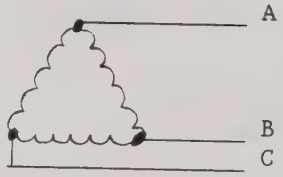
The standard cable supplied with the KH-Drive is 10 feet in length. If you need a longer length cable it may be purchased from Compumotor in lengths up to 100 feet. If you wish to make up your own cable, 12 gauge or larger stranded wire should be used for lengths up to 100 feet. Lengths above 100 feet are not recommended.

The KH-drive is configured to handle either delta or wye wound motors. Motor winding inductance must be at least 1 milihenery per phase.

wye connections



delta connections



NOTE: THE GROUND FOR THE 3 PHASE POWER MUST BE THE SAME AS THE GROUND FOR THE SINGLE PHASE POWER. If this is not the case a ground fault is possible that will not blow the fuses and may start a fire. Contact Compumotor for further details about configuring the KH-Drive for situations other than those provided for at the factory.

B. Resolver Connections

A preassembled 50 foot cable is supplied for connecting the resolver to the Drive. This cable has an MS style connector on the motor/resolver end and a 9-pin D type connector on the drive end.
The MS type connector should be connected to the motor mounted resolver connector and securely tightened. The 9-pin D connector should be connected to the mating resolver connector on the Drive and secured

with the two captive mounting screws.

KH RESOLVER CABLE

Resolver	Wire color	MS	MS	Wire Color	9 PIN D
R1	red/white	A	A	white	4
R2	yellow/white	B	B	brown	9
S4	blue	C	C	blue	3
S2	yellow	D	D	green	6
S1	red	E	E	red	1
S3	Black	F	F	Black	7
		G	G	Shield	5

Connector is MS3102A 14S-6S for KH Motors

C. Line Power Connections

AC power is connected to the screw terminal connector on the front panel. The 240 V.A.C. three phase power connection wire should be at least 12 gauge stranded wire. The 110 V.A.C. Single phase should be connected with a 14 gauge stranded wire.The wires should be connected to the screw terminals as follows:

120 VAC single-phase power, (100 V.low line, 130 V. high line)

Terminal	NAME	Wire color
LINE	120 VAC LINE	Black (blue)
NEUT	120 VAC NEUT	White (brown)

240 VOLT A.C. THREE PHASE (200 V. low line, 250 V. high line)

Terminal	Function	Wire color
PHASE 1	240 V PHASE A	BLACK (blue)
PHASE 2	240 V PHASE B	RED (brown)
PHASE 3	240 V PHASE C	WHITE (yellow)
GND	Earth ground	GREEN (green or green with yellow)

AUXILIARY 4 Pin Entrelec

1	DRIVE FAULT+ (N.O.)
2	DRIVE FAULT- (COM.)
3	DRIVE ENABLE-
4	DRIVE ENABLE+

INDEXER 25-pin 'D' connector, female.

1	-- STEP+
2	-- DIRECTION+
3	-- n.c.
4	-- n.c.
5	-- SHIELD
6	-- n.c.
7	-- FAULT RESET+
8	-- n.c.
9	-- DRIVE FAULT+
10	-- SLIP FAULT+
11	-- n.c.
12	-- RESERVED
13	-- n.c.
14	-- STEP-
15	-- DIRECTION-
16	-- REMOTE POWER SHUTDOWN+
17	-- REMOTE POWER SHUTDOWN-
18	-- n.c.
19	-- FAULT RESET-
20	-- n.c.
21	-- DRIVE FAULT-
22	-- SLIP FAULT-
23	-- n.c.
24	-- n.c.
25	-- n.c.

RS-232 25-pin D connector, female.

1	-- N.C.
2	-- RECEIVE
3	-- TRANSMIT
4	-- N.C.
5	-- N.C.
6	-- N.C.
7	-- GROUND
8-25	-- N.C.

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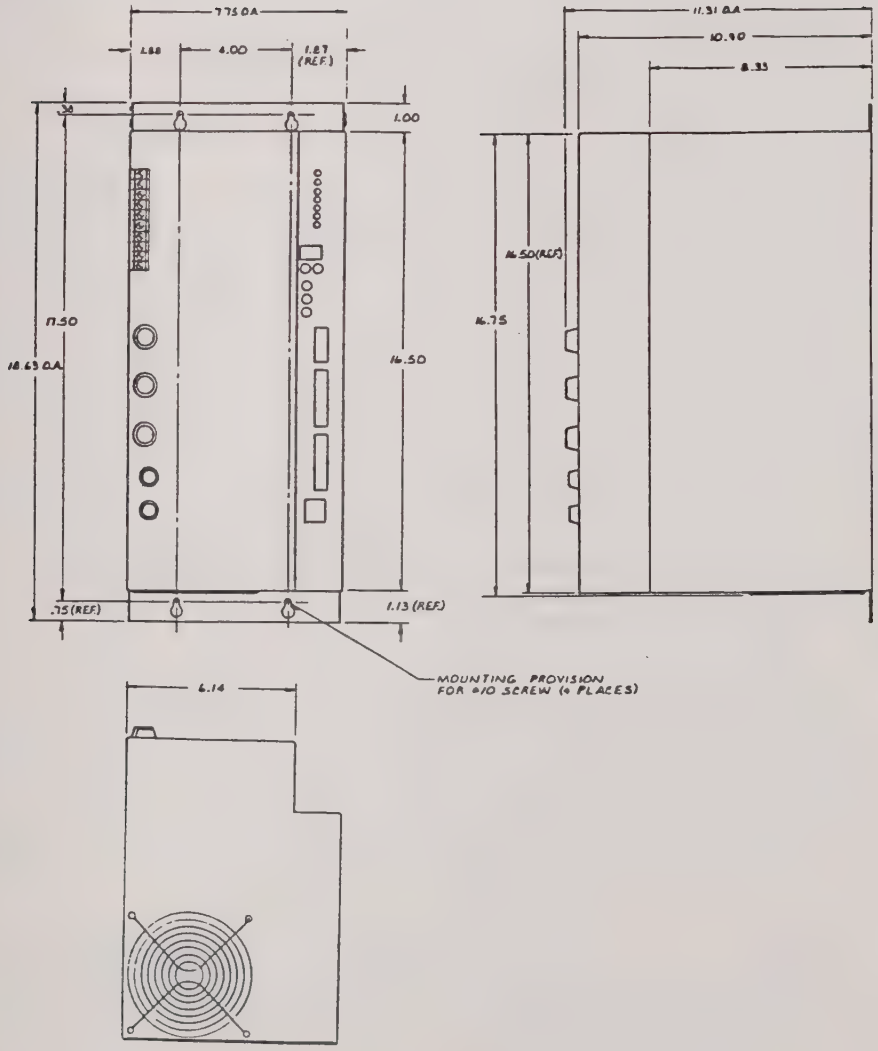
APPENDIX B
KH-Series DIMENSIONAL DRAWING

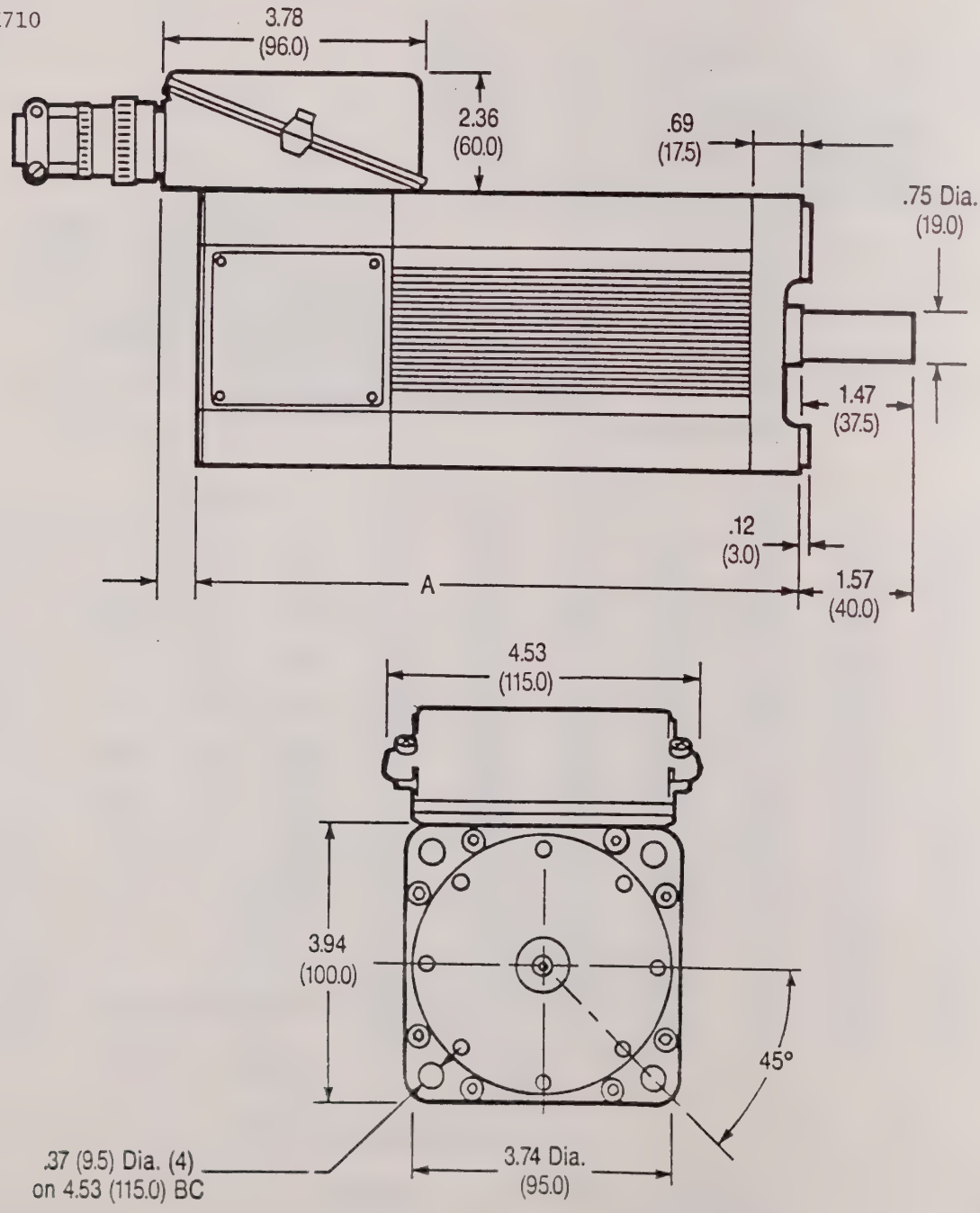
DRIVE DIMENSIONS



APPENDIX B
(Continued)

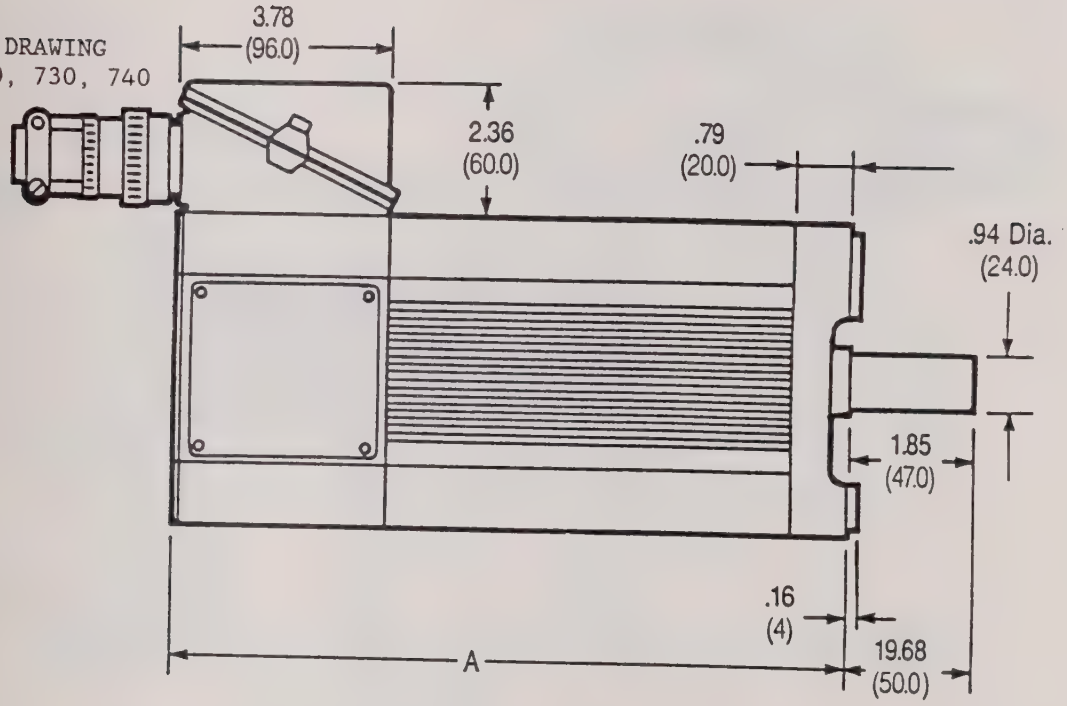
MOTOR DRAWINGS

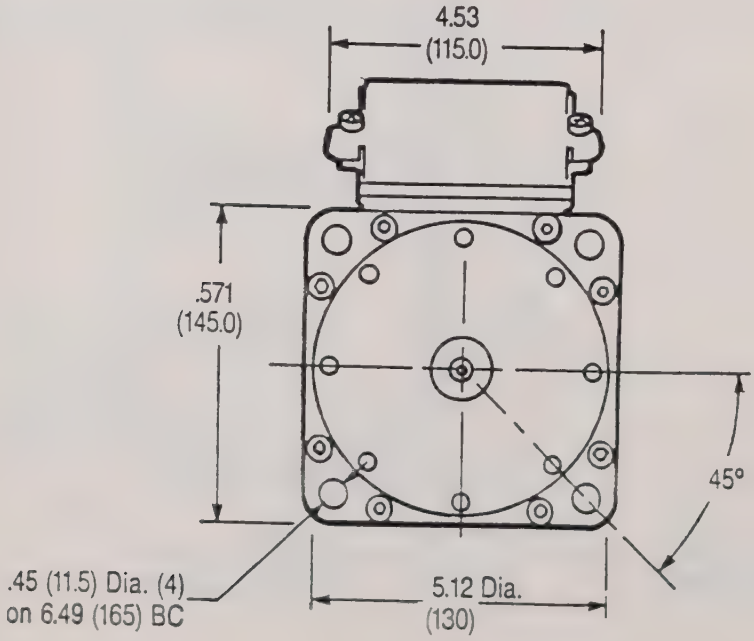
KH710



APPENDIX B
(Continued)

MOTOR DRAWING
KH 720, 730, 740

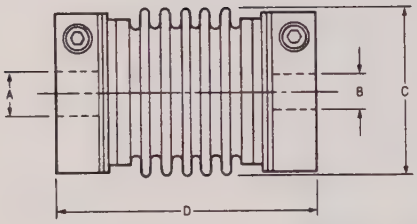




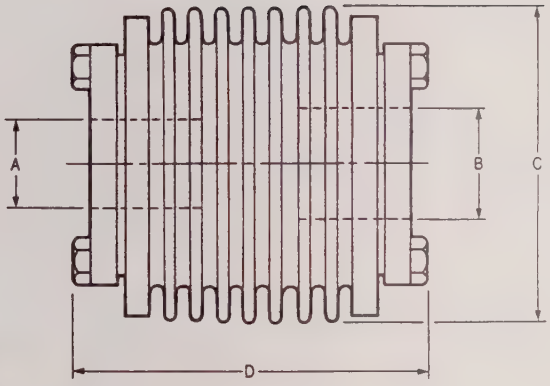
APPENDIX B
(Continued)

COUPLER MECHANICAL DRAWINGS

Coupling Model No.
CPG2
CPG4
CPG8
CPG12



Coupling Model No.
CPG20
CPG30
CPG80
CPG170



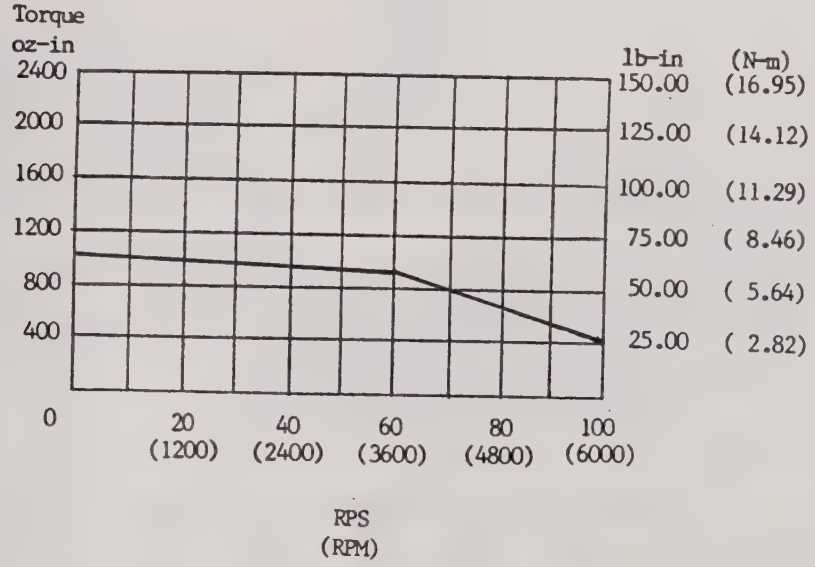
Coupling Model No.	Motor Model	A Shaft Size inch	A Shaft Size mm	B Output Bore Dia inch	B Output Bore Dia mm	C Outer Dia inch	C Outer Dia mm	D Overall Length inch	D Overall Length mm	Inertia oz-in²	Inertia 10⁻⁶kgm²
CPG2-4	KS-210	0.276	7.000	0.250	6.350	0.984	25.000	1.654	42.000	0.252	4.600
CPG2-6				0.375	9.525	0.984	25.000	1.654	42.000	0.252	4.600
CPG4-4	KS-220	0.276	7.000	0.250	6.350	0.984	25.000	1.713	43.500	0.252	4.600
CPG4-6				0.375	9.525	0.984	25.000	1.713	43.500	0.252	4.600
CPG8-10	KS-230	0.551	14.000	0.625	15.875	1.575	40.000	2.343	59.500	2.187	40.000
CPG8-12				0.750	19.050	1.575	40.000	2.343	59.500	2.187	40.000
CPG8-10	KS-240	0.551	14.000	0.625	15.875	1.575	40.000	2.343	59.500	2.187	40.000
CPG8-12				0.750	19.050	1.575	40.000	2.343	595.00	2.187	40.000
CPG12-10	KS-250	0.748	19.000	0.625	15.875	1.575	40.000	2.441	62.000	2.187	40.000
CPG12-12				0.750	19.050	1.575	40.000	2.441	62.000	2.187	40.000
CPG20-10	KS-260	0.748	19.000	0.625	15.875	2.205	56.000	2.520	64.000	9.295	170.000
CPG20-12				0.750	19.050	2.205	56.000	2.520	64.000	9.295	170.000
CPG30-12	KH-710	0.748	19.000	0.750	19.050	2.598	66.000	2.795	71.000	16.402	300.000
CPG30-14				0.875	22.225	2.598	66.000	2.795	71.000	16.402	300.000
CPG80-14	KH-720	0.945	24.000	0.875	22.225	3.228	82.000	3.110	79.000	32.805	600.000
CPG80-16				1.000	25.400	3.228	82.000	3.110	79.000	32.805	600.000
CPG80-14	KH-730	0.945	24.000	0.875	22.225	3.228	82.000	3.110	79.000	32.805	600.000
CPG80-16				1.000	25.400	3.228	82.000	3.110	79.000	32.805	600.000
CPG170-14	KH-740	0.945	24.000	0.875	22.225	3.228	82.000	3.150	80.000	32.805	600.000
CPG170-16				1.000	25.400	3.228	82.000	3.150	80.000	32.805	600.000

APPENDIX C

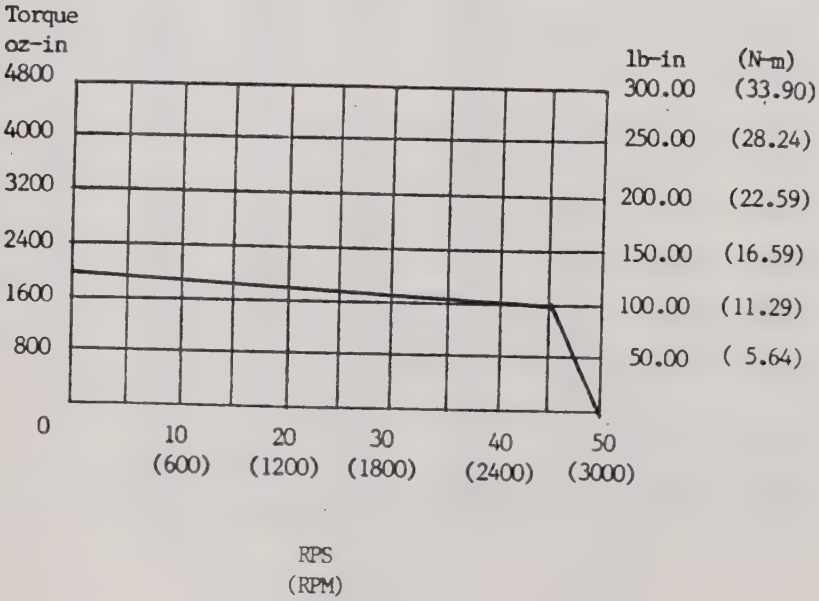
TORQUE SPEED CURVES

KH 710 @[redacted] [redacted] 240 VAC

KH-710



KH-720

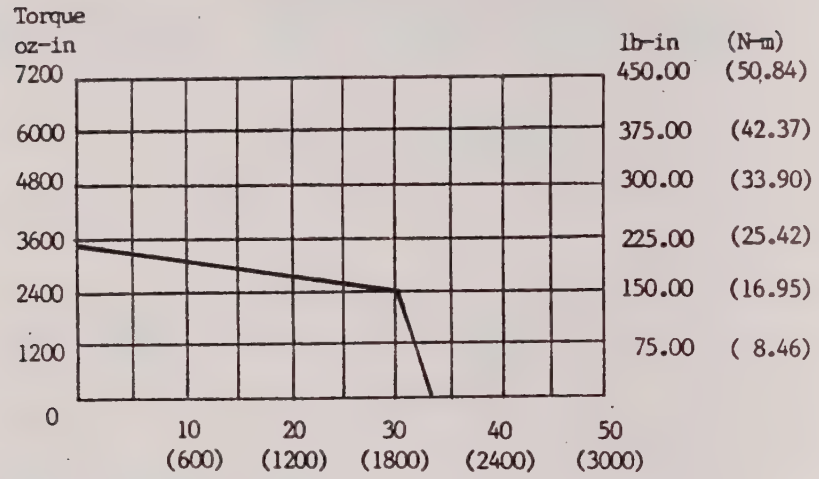


APPENDIX C
(Continued)

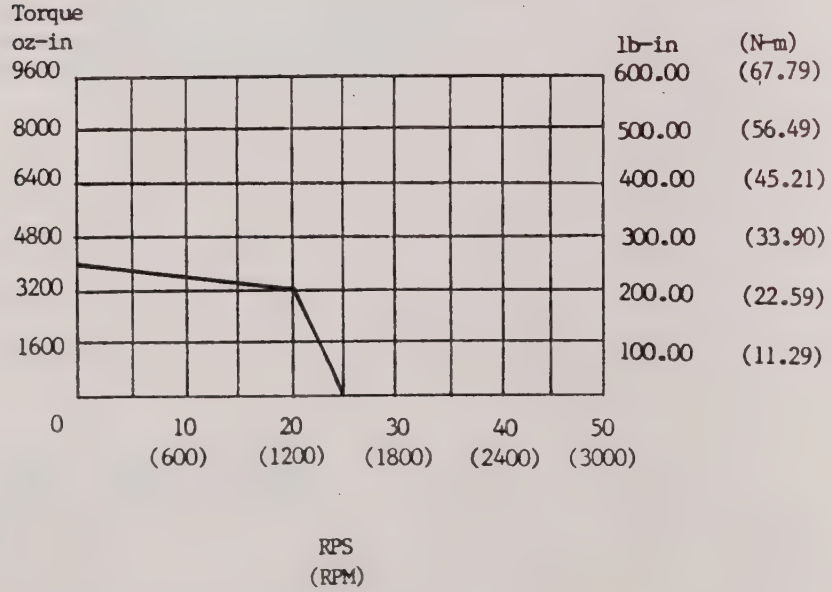
TORQUE SPEED CURVES

KH MOTORS

KH-730



KH-740



APPENDIX C
(Continued)

VELOCITY RIPPLE CURVES

KH MOTORS

NOT AVAILABLE AT

THIS TIME

APPENDIX D

SUMMARY OF ERROR CONDITIONS

The following summaries list all the abnormal conditions one may encounter with the KH-Drive. Under each condition is a list of the indicators for that condition.

Operation Error Conditions

SLIP FAULT:

Indexer SLIP FAULT output = ACTIVE

SHUTDOWN:

Indexer FAULT OUTPUT = ACTIVE
DRIVE FAULT LED = ON

ERRORS AND FAULTS:

Indexer FAULT OUTPUT = ACTIVE
Auxiliary FAULT OUTPUT = ACTIVE
DRIVE FAULT LED = ON
ERROR LED = ON
"RSE" messages --
"Temp. and/or current limits exceeded"
"Maximum following error exceeded"
"Average current limit exceeded"
"STEP pulses detected during enable"

Hardware Error Conditions

POWER/FUSES:

STATUS LED = OFF

MICROPROCESSOR:

STATUS LED = RED

CONTROLLER:

Indexer FAULT OUTPUT = ACTIVE
Auxiliary FAULT OUTPUT = ACTIVE
DRIVE FAULT LED = ON
ERROR LED = ON
"RSE" Messages --
"RAM failed initialization"
"EEPROM failed CRC check"

APPENDIX E

SERVO COMMAND SUMMARY
****

E	Enable the RS-232.	36
F	Exit the RS-232 mode and return to front pannel	36
ST0	Turns the power amplifier off.	37
ST1	Turns the power amplifier on.	37
RFS	Returns the drive to factory settings.	37
HELP	Returns help menu	37
RSE	Reports servo errors.	37
Z	Resets the drive.	37
RV	Software Revision level reported.	37
CMTR	Configure/report Motor type	38
FMCA	Find motor commutation angle	39
CMR	Configure motor resolution definition/report	39
CCA	Configure current, average, limit- Definition/report.	40
CDB	Configure DeadBand definition/report.	40
CPE	Configure position error definition/report	41
CVG	Configure velocity gain definition/report.	41
CDG	Configure differential gain definition/report.	41
CIG	Configure integral gain definition/ report.	42
CPG	Configure proportional gain Definition/report.	42
CVM	Configure velocity maximum. Definition/report.	42
CDM	Configure differential maximum Definition/report.	42
CIM	Configure integral maximum Definition/report.	42
CPM	Configure proportional maximum Definition/report.	42
DCA	Periodically displays/reports current (average) in Amperes.	43
DCI	Periodically displays/reports current on and instantaneous basis	43
DPA	Periodically displays/reports the actual position.	44
DPE	Periodically displays/reports position error.	44
DPR	Periodically displays/reports the resolver position.	44
DPS	Periodically displays/reports the position setpoint	44
DIC	Periodically displays/reports indexer counter	44
DVS	Periodically displays/reports the velocity setpoint	45

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